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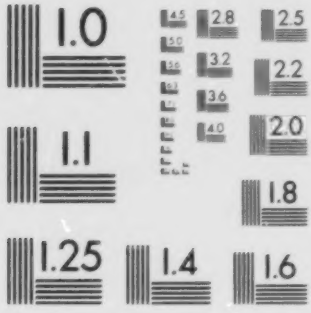

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The Imperative

G. Bruce Doern
Editor

C.D. Howe Institute

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The Environmental Imperative

Market Approaches to the Greening of Canada

G. Bruce Doern
editor

Papers presented at a conference on "Environmental Policy and the Energy Industries in Alberta," Calgary, Alberta, January18–19, 1990

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Foreword

At last, environmental issues are entering the public policy mainstream. Acid rain, poliuted waters, declining fish stocks, and bursting garbage disposal sites have alerted Canadians to the fragility of the enormous geographic tract they inhabit. But the desire of almost everyone to "do something" has not led thus far to any consensus about the appropriate ways to deal with the problems. And confusion abounds. In the aftermath of the National Energy Program and in the midst of an international swing to market-based economies, there is an understandable reluctance in many quarters to entrust the solutions to government and to "command-and-control" approaches.

In a way, the conference that laid the foundation for this book was an outgrowth of the Energy Options process instituted by then-Minister of Energy, the Hon. Marcel Masse. That process began a dialogue among all who had an interest in energy policy. It also commissioned research, and issued a public report setting out the principles informing energy policy over the very long term. Among the enduring achievements of the process was the opportunity it successfully afforded energy industry executives to meet, debate, and come to understand the concerns of the multifaceted environmental movement. The environmental component of the report reflected something of a new consensus established on a higher plane.

But that was just a beginning. It took a gathering of industrialists, scientists, technologists, economists, and political scientists to explore the specifics of public policy, as these

apply to the energy industry. The C.D. Howe Institute convened such a conference in Calgary in January 1990. It dealt with scientific uncertainty, with incorporating the costs of "using" the environment, and with the interrelationships among markets and prices, technological innovation, the environment, and the economy.

There are no simple answers. But there is no reason to despair, either. This book marks but one of a series of initiatives whereby the Institute will continue to refine and delineate the issues, providing its members and the public with the guidelines to inform the evolution of environmental policy in the crucial period ahead.

The Institute's environmental program will be led by G. Bruce Doern, the distinguished Professor of Public Policy at Carleton University's School of Public Administration and a Scholar-in Residence at the Institute, and by my associate, Robert C. York, a Senior Policy Analyst.

The Institute wishes to acknowledge its gratitude to Bruce Doern, who accepted my invitation on the spot in Calgary to oversee the project and guide it through to publication. Barry A. Norris provided the editing and desktop publishing.

As with all Institute publications, the conclusions presented here are the responsibility of the authors, and do not necessarily reflect the opinions of the Institute's members or Board of Directors.

Thomas E. Kierans
President

Getting It Green: Canadian Environmental Policy in the 1990s

G. Bruce Doern

Canada enters the 1990s in the midst of its first serious confrontation with the realities of good environmental policy-making. The papers in this volume are best seen in the context of six features of the environmental policy process. Each deals with a central aspect of Canadian political and economic life — political parties and public opinion, markets and the choice of policy instruments, federal-provincial relations, environmental interests and policy consultation, problems of scientific and technological controversy, and the cabinet-bureaucratic decision process. They are all part of the environmental puzzle and, hence, of the practical task of getting it green.

The Greening of Partisan Political Competition: Parties and Public Opinion

In the 1970s and 1980s, environmental policy was essentially a marginal object of partisan competition (Paehlke 1989). After a brief flurry of interest in the early 1970s, all three national parties put environmental issues on the back burner. This is

not the case as the 1990s begin — the greening of Canada's parties is now well under way. Three related political factors account for the greening of partisan politics now.

First, each national party, trying hard to keep up with public opinion, contains a core body of support that believes deeply in the need to rethink all of our public policies and private actions in terms of "sustainable development," the concept given prominence by the Brundtland Commission (World Commission on Development and Environment 1987). This is true even though there is no precise, universal agreement as to what sustainable development is (Pearce et al. 1989). Under no circumstances, however, should this core of opinion be thought of as some 1990s' version of 1960s' leftist policy. The span and depth of opinion defies categorization along old left-right or partisan lines (Pepper 1984; Toner 1990).

Second, because of the daunting federal fiscal deficit, the public policy agenda is such that it will be difficult for any party to deliver political "good news" regarding social policy except, perhaps, that which might emanate from environmental initiatives. Since other social welfare improvements are unlikely in the short to medium term, environmental policy is likely to be a key point for competition among parties all anxious to demonstrate their environmental credentials. This is not to imply that environmental initiatives will not also be expensive, but the federal government's own polling data suggest that the environment is one area for which Canadians might accept higher taxes and spending.

But environmental competition among parties, at both the federal and provincial levels, cannot be understood just in terms of tactics. It is reinforced by a third, intensely psychological, factor. After a decade of government bashing, some

deserved and some not, Canadians want reassurance that their politicians are capable of dealing with important national issues. In the 1980s, a majority of Canadians supported the superiority of markets in areas such as free trade and energy policy. But they know in their political soul of souls that, on environmental issues, it is government that must take the lead.

Policy Implementation, Markets, and Instrument Choice

The intensity of public opinion in support of stronger environmental action cannot be denied — Canadians are, in fact, miles ahead of their politicians and rightly want political leadership on this issue. This is an enormous asset, since, without support for the underlying values, no progress is possible. At the same time, however, the public is still miles behind in understanding the fundamentals of how to *implement* environmental policy.

The purpose of good policy implementation is to ensure that desired changes in behavior actually occur in an entrenched way over the long term. It is not enough to enjoy some short-term titillation at the sight of the occasional corporate executive's being jailed for gross violations of pollution laws — such "heroes-and-villains" approaches do not work. Everyone's behavior must change, and policy instruments must be varied and sensible if they are to be effective, efficient, and politically legitimate.

There are several reasons for the pressing need for education and thought on this weakness in public opinion. First, as Don McFetridge carefully points out, there is an enormous gap between myth and reality regarding two points central to the

environmental debate. One concerns the notion that government is superior to markets in taking a long-term view of environmental problems. The evidence does not suggest that this is true (Dewees 1983). Government leadership is needed to establish framework laws, but market mechanisms are needed for actual implementation. In many situations, the objective should be to establish clearer property rights and proper pricing mechanisms. The second point concerns the illusory notion of the often-cited principle of "let the polluter pay." McFetridge shows how, in practical terms, the cost of pollution is, in fact, widely dispersed.

But, as both McFetridge and Arlon Tussing rightly point out, it is not just that a "command-and-control" approach will not work and that a market-based incentives and pricing approach must be central. The same conclusion ultimately emerges from a practical "bottom-up" mapping in the public's mind of just how numerous and complex are the industrial production routes and physical paths for each possible or real environmental hazard and for each product sold and transported (Doern, Prince, and McNaughton 1982). Multiply these hazards several thousandfold, and only then will the average Canadian begin to have some realistic sense of the numerous points at which behavior must gradually change and be induced, rather than be forced, to change.

Education and thought on public attitudes is also required because of the need to pay attention to what Albert Hirschman (1982) refers to as the theory of "citizen-consumer disappointment." By this, he means the experience over historical cycles in which citizens in Western democracies have opted alternatively for bundles of public and then private goods. Using Hirschman's terminology, the broad relative shifts in prefer-

ence are due not just to ideological preferences between left and right or between pro-state and pro-market inclinations, but even more to collective bouts of disappointment with what *both* government and markets deliver. In the 1980s, disappointment was first applied to a bundle of public goods. But as the 1990s begin, disappointment is being registered over some features of what markets delivered in the 1980s — too many homeless, insider trading, greater environmental degradation. The trick is to reduce the amplitude of these swings so that both the state and markets do not consistently disappoint.

While this is obviously easier said than done, it is important to recognize the phenomenon explicitly — especially regarding environmental policy, where the combination of a sense of steady and demonstrable progress is vital to maintain optimism. At the same time, the task is so large that the disappointment cycle may kick in all too soon.

It is evident from meetings and discussions between environmentalists and business interests that there is still considerable mutual ignorance about how alternative environmental policy instruments actually work. Both McFetridge and Richard Lipsey examine the range of available instruments, including emissions charges, abatement subsidies, and tradable or marketable effluent permits — economists seem to favor the last of these, in particular (Block 1990). But such instruments also evoke opposition, in part because they are not understood, in part because there are examples of both success and failure in their use, and in part because they evoke the contending views of morality implied in principles such as "let the polluter pay."

McFetridge draws attention to the opposition of environmentalists, but Lipsey also points out why business also often

opposes these market-based policy tools. He suggests three reasons for their opposition. First, where a charge is involved, business may simply regard this as just another tax grab. Second, businessmen as individuals may feel the same sense of injustice as do other citizens if they have to pay more than others for their polluting activities. And third, a sense of injustice may emerge if competitors continue to pollute while they do not.

While it is true that, overall, market incentives are more likely to be needed to secure real and lasting environmental change, economists are nonetheless also somewhat naive in their understanding of the political importance of "command-and-control" regulatory approaches. In the first instance, it is important to stress that environmental policymakers are not starting from scratch — numerous command-and-control laws and regulations already exist. Moreover, there are serious issues involving where the legal burden of proof ought to reside on environmental matters. Thus, the state's more coercive intrusions are not just the outcome of irrational thinking by naively moralistic environmentalists. There are indeed some environmental villains with whom politicians will be pressed to deal in more resolute ways.

Federal-Provincial Relations: An Environmental "NEP"?

As the federal government prepares its promised new environmental policy, it is already being accused, especially in Alberta, of launching an environmental version of the unilateral National Energy Program (NEP) of 1980 (*Alberta Report* 1990).

Likening federal environmental initiatives to the NEP strikes a raw nerve in Alberta politics, for three reasons.

First, there is concern that new environmental initiatives will constitute a federal grab for provincial powers, especially in the field of natural resources. Second, there is fear that the energy industry will be an inviting target for new discriminatory taxes, including a carbon tax on the oil and gas industry. And third, there is suspicion that federal policy will be imposed unilaterally, urged on by a new environmental bureaucracy in Ottawa headed by former federal energy officials.

While the expression of such concerns is yet another reminder of the political damage done by the NEP, there are several reasons for arguing that the situations are not, in fact, similar.

First, the federal government is beginning a process of consultations, a process that will be heightened once it has thought through the basic contours of its own position. It is natural that the federal cabinet has taken considerable time over this, since the issues regarding an overall environmental strategy are indeed difficult for ministers to resolve.

Second, the jurisdictional issues involved are very different than was the case in energy policy. Environmental policy deals horizontally with all sectors of the economy. It thus has far less of the "one-on-one" confrontational flavor that was evident in issues of resource and energy ownership. Federal and provincial powers under the Canadian Constitution are both involved, making the environment a situation of *de facto* and *de jure concurrent* powers.

Third, on environmental matters, intraprovincial politics bear little resemblance to the battles over the NEP in 1980. Conflicts will indeed occur *within* provincial governments be-

tween producer interests and environmental interests, but provincial environmental ministries will often need allies to maintain pressure, including a strong federal environmental presence. Thus, some supportive federal-provincial alliances among environmental agencies will likely occur because they will need each other for political leverage.

Moreover, if the NEP taught Canadians anything it is that rancorous federal-provincial conflict produces bad policy and is in no one's long-term interest. The need for extensive federal-provincial (and local government) cooperation in the environmental policy process is evident in several ways.

First, it is compelled by the sheer number and geographic dispersal of pollution sites and situations. This calls for decentralized approaches and for national and international standards and/or target setting. Lipsey usefully reminds us of how vital it is to match particular environmental problems with the appropriate level of jurisdiction, depending on whether the problem is global, continental, or local. As he points out, environmental solutions will fall far short of the mark if the jurisdiction is "ineffectively small or inefficiently large."

Second, and more concretely, federal-provincial cooperation is necessitated by the research effort and enormous amount of scientific and technical data needed to underpin the basic regulatory and monitoring functions of government. No single level of government can afford to do this, but the primary obligation here resides with the federal government. Ottawa cannot turn its environmental scientific capacity on and off at the whim of each budgeting exercise (Smith 1990).

And last, but certainly not least, there has to be extensive federal-provincial cooperation on enforcement and inspection. Even if the environmental policy regime of the 1990s is char-

acterized, as it must be, more by incentives than by command and control, there will still be an enormously increased need for cooperation in the realm of inspection and compliance regimes and philosophies, and for determining priorities among industries or types of pollutant or hazard in each province.

Environmental policy presumably would not be Canadian if it did not introduce some modest amount of the "politics of blame" into federal-provincial policy relations. Fortunately, the prospect of a healthier game of the "politics of claiming credit" in environmental matters also exists.

Environmental Interests and Public Consultation: Slowing Down the Decisionmaking Process?

As the 1990s begin, there is still a tendency for simplistic mutual stereotyping among environmental interests. As Toner (1990) has shown, however, the spectrum of environmental interests is far more complex and subtle than the usual rhetorical labels will admit.

Environmental interests range along a continuum, with environmental interest groups on one half of the spectrum and business interests on the other. But on both sides there are important degrees of difference in their public stances and actions reflecting a form of mutual learning and education, especially during the 1980s.

For example, among environmental interests, one finds groups or players that range ideologically and tactically from Greenpeace to Energy Probe to conservationist and naturalist groups. On the business side, one finds interests that range

from firms with demonstrably bad pollution records and practices to major firms and industries with exemplary records. The business side also includes a growing environmental industries sector (suppliers and consultants), as well as a green retail products services sector. Thus, the structure of interests is now quite complex and a far cry from the polar extremes of the late 1960s, when environmental groups tended to be "no-growth" oriented and business regarded such groups as naive and even dangerous.

Even this national spectrum of interests tells only part of the story. At the provincial and regional levels, industry interest groups have also noted a significant change. The participants in this C.D. Howe Institute conference heard Ian Smythe of the Canadian Petroleum Association — the country's largest oil and gas interest group — say that the Alberta Environmental Network had grown to 280 member groups from 80 in the mid-1980s. In Western Canada as a whole, there are now over 1,200 such groups. Smythe concluded that these groups are much more "cross-cultural" and varied, with the people involved "concerned about one thing and that is the quality of life in their community and what development may do to it." He then went on to stress that "in looking at environmentalists, one has to begin to disaggregate that rather lumpy term."

In the broader public debate on the environment, there is probably little appreciation of the degree to which increased communication among environmental interests has in fact occurred. But from the early 1980s on, several important consultative exercises have broadened the base of mutual knowledge and created important personal networks between business and other environmental interests (Toner 1990). Elaborate exercises such as the Niagara Process launched by

the Liberal government early in 1984, the 1986–87 National Task Force on Environment and Economy, the Energy Options review process in 1987–88, and subsequent national and provincial environmental roundtable processes all exemplify an important public learning process.

All of these developments simply lend additional weight to the simple fact that environmental policymaking is as much about how decisions are made as it is about the content and impact of decisions. While this statement is in many ways true about all democratic policymaking, it takes on additional meaning in the environmental sphere because of the larger historical lack of basic trust among the interests involved. This lack of trust was especially manifest in the dynamics of public hearings over major projects. From the Berger Inquiry of the mid-1970s to the current court decisions over the Rafferty-Almeda Dam, project developers, environmental groups, local citizens groups, provincial governments, and the federal government have only begrudgingly tolerated each other.

The issue of hearings on large development projects raises the inevitable problem of the appropriate speed of the environmental decisionmaking process. In the long term, if new consultative habits become entrenched among all players, there is no need for environmental decisionmaking to slow down the public decision process. But in the short term, the likelihood is that the process will, and even should, be slowed. It is only through considered and deliberative hearing, assessment, and consultation processes that further trust will be built, that errors will be corrected, and that both developmental and environmental sustainability goals can be achieved.

Such processes are essential precisely because of the ingrained character of environmental decisions. Not only will it be necessary to determine in a practical way just what sus-

tainable development means in any particular project or situation, but, as is discussed in more detail later, processes will have to be built in to handle the problems of scientific and technical controversy that automatically arise.

The second likely reason for the need for slower decision-making processes is that designing the appropriate policy instrument packages will take time and should be transparently arrived at. Since such packages could include an array of devices in any given situation, industry, or location — fees, pollution rights, taxes, standards, memorandums of agreement — they will also need proper arenas for consensus building, and in the short term as well, for public and corporate education.

If none of these is a compelling reason for treating the environmental decisionmaking process seriously, then one further element should concentrate the mind: citizens and interests will take court action themselves. Thus far, Canada's political culture has not produced a litigious society on the U.S. model, but with the Charter of Rights and the strong views held about environmental values, this legal serenity seems likely to end. The hands of both government and business are increasingly likely to be forced. It is best, then, for both corporate and governmental institutions to reform their internal decision-making processes, as many are already doing.

Science and Technology: The Ham in the Environmental Sandwich?

Stuffed between environmental groups and the business community are scientists and technologists working and advising in government, industry, academia, and independent insti-

tutes. As knowledge experts, they too are in some respects an interest group, albeit a diffuse one. But they find themselves at the vortex of conflicting expectations in the environmental debate. This is because many people see science and technology as both the cause of environmental degradation and the solution to environmental reform. Kenneth Hare shows that, on an issue such as global warming and the greenhouse effect, science has been incapable of keeping up with the sudden escalation of interest and concern among world political leaders. In short, politicians are way ahead of the requisite science but seem unaware of that fact.

The dilemma in the environmental equation is that science and technology is not just an assemblage of knowledgeable people. It is also a process of peer-group assessment and experimentation that is intended to produce a form of objective knowledge. And yet, as Hare reminds us in his review of the kinds of knowledge extant in the greenhouse debate, environmental science is rife with uncertainty. He has no difficulty in concluding that global warming is occurring and that it would be prudent to take appropriate action on a global scale. At the same time, however, he shows how knowledge is not sufficiently precise to provide policy guidance on a regional or local level within Canada. Yet, spatially specific knowledge is necessary for provincial and national governments and for corporations to act intelligently. Hare argues that greater priority needs to be given to expanding basic and continuous monitoring activity, at task which ultimately will fall to government.

While Hare focuses on science in the context of the greenhouse debate, Norman Ball spotlights some of the dynamics inherent in engineering and technology by bringing us more into the realm of basic business production processes and

industrial change. He shows through several, somewhat more anecdotal, cases that technology need not be feared in the environmental debate. This is especially true if one realizes that technological production processes also contain strong norms and practices favoring safety and protection, even though these practices and principles are often little understood by the lay public.

Ball also cautions against such simplistic notions as the assumption that basic science leads to technological innovation. History suggests that there are numerous instances where the reverse is true. Thus, the serendipitous nature of science and technology must be appreciated. Rather than proceeding from any inherent belief in the superiority of markets, Ball concludes more on actual technological grounds that there is little alternative but to rely heavily on business for leadership on the overall environmental issue.

Both Hare and Ball are right in urging laypersons to come to grips with the actual dynamics of science and technology, and so to demystify the role of scientists and technologists. In my view, however, they place insufficient emphasis on another key institutional problem where science and the environment meet.

Often discussed under the topic of the "politics of scientific and technological controversy" (Doern 1981), this problem refers to the issue of how the public decisionmaking process actually goes about separating genuine scientific and technological disputes — where "causal knowledge" is truly uncertain — from disputes involving material interest — where scientists are hired guns whose role is to disguise economic disputes. These disputes are legion in the history of regulating environmental and occupational health. The designers of hearing

processes or consultation exercises will have to pay more attention to how such disputes can be aired more fully, if not resolved. Otherwise, the prospect is for an increasing politicization of science and scientists.

Cabinet Decisionmaking Processes: Projects *versus* Policies?

The discussion above of environmental decisionmaking referred primarily to decisions about projects. Canadians have now accumulated about two decades of institutional experience on major projects, primarily under various environmental assessment acts (Brown 1986; Fenge and Smith 1986). However, hearings and assessment processes are set out for projects, but not for the policies that guide projects or other governmental regulations and programs. The question arises whether these processes ought to apply to policy development at its earliest stages of gestation within the federal cabinet and bureaucracy and whether — and if so, to what degree — it should be made a legal requirement imposed on the cabinet.

In the current federal discussions, Environment Minister Lucien Bouchard has sought to entrench legally some form of environmental assessment process for all policies (Bregha et al. 1990). There is no doubt that this would radically alter cabinet decisionmaking. Not surprisingly, it is being resisted within the Ottawa system on three grounds.

First, some line ministers and departments are opposed simply on the grounds that it sacrifices their policymaking independence and discretion at the alter of a policy value, "sustainable development," whose meaning in practical situations will be unclear or which they perceive will be at odds with

the core of their departmental mandate. Second, departments such as Finance and Industry, Science and Technology are resisting in part because of a fear that it will lead to demands that will deflect attention away from the primary economic challenges facing Canada — namely, the deficit and this country's industrial competitiveness in the wake of free trade. Third, the Privy Council Office and other defenders of traditional cabinet-style government argue that one cannot have a law on a cabinet-wide basis that somehow purports to tell what cabinet members ought to take into account in making decisions. According to this argument, one might then equally have laws that force the cabinet to give primacy to regional values or to efficiency and "value-for-money" criteria.

These conundrums are real and, at present, it is unclear how far the legislation will go. Environmental interest groups regard this provision as being the acid test of the government's seriousness. Much depends here on how differently one treats the imperative of environmental values as opposed to other values that are also a part of Canadian political and social life. My own view is that statutory entrenchment of some kind is desirable and worth the risk. It may well lead to some *pro forma* ritualistic environmental assessments. Equally, however, it will help kick-start the federal cabinet and senior bureaucracy into developing environmental habits as a forethought rather than an afterthought in the policy formulation process.

By highlighting in these papers six features of Canadian environmental policy in the 1990s, each corresponding to a crucial element of the Canadian political and economic system, we have by no means covered all aspects of the environmental puzzle. International policy and decision processes are obviously crucial. So are local government dynamics such as the

NIMBY ("not in my backyard") and NIMTOF ("not in my term of office") syndromes. Overall, however, the message is clear: environmental policy is no ordinary policy field to be resolved in the 1990s by "business-as-usual" approaches or by "command and control" rhetorical sloganeering.

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Environmental Uncertainty: Science and the Greenhouse Effect

F. Kenneth Hare

It must be exasperating to be a Minister of the Environment, or the Chief Executive Officer of an environmentally sensitive corporation. Such people turn to the scientist for what they hope will be facts about the environment. All too often, they get conflicting advice, some of it transparently tendentious. Even when they go to the top authorities, they may get cautious, elliptical replies. I have heard Ministers explode about this, and I sympathize with them. So I want to ask two questions: Why is there so much uncertainty about environmental science? And how can we take such soft advice seriously, and then act on it?

The idea that science deals in certainty is, of course, wide of the mark. Scientists search for it, yearn for it, sometimes even believe they have found it. But the search for truth is always self-defeating, and certainty implies that you have closed the door on new understanding. The truth about nature is science's Holy Grail. You never find it, yet you go on trying until you are dead. Do not expect me to announce any truths in this paper. But I do not expect to tell any lies, either.

The uncertainty in environmental matters is pretty daunting. This is especially so when we try to predict future environ-

ments, or the consequences of specific policies. Old weather forecasters like me (and economics Nobel Laureate Ken Arrow) are used to being wrong. In our defense, I should say that economists make similar mistakes, with even bigger consequences, and get paid better while doing it. And where would medicine's reputation be if doctors had to broadcast their diagnosis and prognosis within an hour of seeing a patient? Where would the markets be if the forecasters were good at their jobs? Prediction in economic, social, political, and environmental systems is atrociously difficult, perhaps in principle impossible. Yet we have to do it, somehow, even at the risk of being damnably wrong, because public policy needs it.

The scientific problem arises in a number of ways, which I will summarize before I look in detail at one particular question, the greenhouse future. Scientists are reasonably sure — which is the nearest they ever get to certainty — of two fundamental principles. One is that the universe, and all that is within it, behaves in accordance with the laws of physics. These are not quite deterministic, but for most purposes they act as such. And the second is that all life is constrained by the properties of its genetic materials, the discovery of which was the most important event of this remarkable century. Scientists are confident, therefore, that we know what governs nature's behavior.

Yet these laws are all but useless in predicting the detailed future of natural complexes such as the oceans, the atmosphere, and the world's ecosystems. This is because both principles allow an effectively infinite set of outcomes in such complex situations. Picking the right one is extraordinarily difficult. All we can do is to look for clues, and keep our eye on events as they unfold. This, by the way, is what we mean by

environmental monitoring, which is absolutely central to the job before us. I find it very hard to explain why we have to go on taking nature's pulse day in and day out. Many scientists reject it because they think that an experiment once done and replicated does not need to be done again. And bureaucrats reject it because monitoring costs money, which they can think of better ways of spending. But I assure you that without the satellites, the research ships, the deep-sea drilling vessels, the network of ground observations, the computers, and the 24-hour, 365-day watch in perpetuity, environmental scientists could not do their jobs, and public policy in the environmental arena would not be worth articulating.

Let me illustrate these remarks by discussing what we know, what we predict, and what we do not know about the greenhouse effect. More than any other scientific hypothesis, it has been the greenhouse effect that has awakened the rest of the scholarly world, politicians, statespersons, and business people to the urgency of environmental policy.

The Greenhouse Effect

The greenhouse hypothesis notes that the earth's surface is kept on average about 33°C warmer than it should be (given its distance from the sun) by the presence in the otherwise transparent atmosphere of the so-called greenhouse gases. These include water vapor, chiefly below 10 km; carbon dioxide (CO_2), at all levels; ozone (O_3), chiefly in the stratosphere; and certain gases derived from the earth's surface, notably methane (CH_4, so central to Alberta's economy), and nitrous oxide (N_2O). These gases let solar energy come in, but retard the return flow of energy to space. So the earth's surface is kept

warm and benign to life by the heat temporarily trapped at low levels and in the surface layers of the oceans.

Human beings have added other greenhouse gases, such as chlorofluorocarbons (CFCs). The kerfuffle of the past few years has arisen because human interference has begun to disturb the chemical balance of the atmosphere and the oceans. CFCs, CO_2, CH_4, and N_2O are all increasing rapidly, in the case of methane by 1 percent per annum. We are adding 3 billion tonnes of carbon to the atmosphere each year. Hence we are adding new panes of glass to the greenhouse. It is this added effect that leads us to predict a warmer world. The natural greenhouse is a thoroughly good thing. It alone keeps the world habitable. But the augmenting of this benign effect is more worrisome. You can have too much of a good thing (Dickinson 1982).

To predict the consequences of this buildup of greenhouse gases, we employ basic physics and chemistry, and some cumbersome mathematics, difficult on even the largest supercomputers. We write down the equations governing the atmosphere's and the ocean's behavior, and solve them numerically for some future epoch, typically when the greenhouse gas concentrations will have doubled (Roberts 1989). There are now about ten center around the world where this can be done (Toronto being one, using a computer in Montreal), and there are about 200 people who know how to do it. Most investigators find similar results: that global surface temperatures should rise between 1.5 and 4.5°C for a doubled greenhouse effect, possible by 2030 to 2050, with least effect in the tropics, and most in northern subpolar regions, notably Canada. There are likely to be important effects on the sea level; on sea and river ice and, hence, on navigation and power development; on

precipitation and, hence, on water supply; on crop and forest growth and health; on energy consumption; and on a variety of less crucial things. I do not believe that such changes could bring the world to its knees, but I am sure that, if realised, they would involve major economic consequences.

The models may, of course, be inaccurate and may give misleading answers. The raw equations that they start from are as hard as nails; they merely embody the known laws of physics and chemistry. But to solve them we need to simplify reality in many ways. It is hard, for example, to couple the atmosphere and the oceans, because they behave quite differently, though they interact to a tremendous extent. And we can never get enough data to define the ground state properly. The role and distribution of clouds, remain hot potatoes, as do volcanic eruptions. The differences between model results largely reflect the different ways in which modelers get round their difficulties. There are leading scientific figures — Bill Nierenberg of the Scripps Institution, Bob Jastrow of the Goddard Institute of Space Studies, and Frederick Seitz of Rockefeller University, for example, or Dick Lindzen of the University of Chicago, or Reid Bryson of Wisconsin at Madison — who say that the models are dangerously misleading and should not be made the basis for new policies or technical change. Governments and corporate officers have tended to love these critics. But most commentators, including myself, feel that the basic thrust of the model results is correct, and must be taken into account.

This thrust points toward a warmer world, with considerable changes of rain and snowfall (on the whole, more precipitation, but perhaps with less available soil moisture in the interior of North America and parts of Eurasia). Unfortunately,

the regional detail is not reliable, and this leads to the first fundamental difficulty: governmental jurisdictions generally cover relatively small parts of the earth's surface and hence need — but cannot get — accurate advice about what will actually happen in their own ballparks. Even big units such as the Canadian federal government face this difficulty. Corporations have the same problem. The climatologists cannot tell them what will happen in their own business area.

What does the scientist do when theory yields no firmly agreed answer? He or she turns to monitoring and observation. These, too, are never fully adequate, because of the low regard in which they are held — although they are improving. And efforts are being made to interpret the record more perceptively. But the first near-certainty can be stated. There is no doubt that a global warming is in progress. With enormous effort and detective skill, several groups around the world have reconstructed surface air temperature changes over the globe since about 1860. These reconstructions incorporate all available observations over land and at sea, and are weighted so as to balance as far as possible differences of observation density and the disturbing effect of city growth. The record preferred here is that produced by Jones et al. (1988) at the University of East Anglia. It shows that global mean annual temperatures have risen about 0.7°C since 1860, and by about 0.5°C in this century. The figure may be as low as 0.3°C, in the view of some critics. But most people think that the warming is real and significant. The 1980s have been especially warm, with six of the ten years having been warmer than any in the previous record. Tied for the warmest on record were 1987 and 1988, at 15.6°C. Nineteen eighty-nine was marginally cooler, at 15.3°C. The warming is thus a matter of record. It is actually

near the lower margin of model forecasts. If it is due to the greenhouse effect, then nature is choosing the most cautious of responses!

It must be stressed, however, that there are surprising differences from year to year, and from decade to decade. The effect is also nonuniform over the earth's surface, though both hemispheres are affected. The 1940s, 1950s, and 1960s were a period of standstill, or even (in the northern hemisphere) of cooling. Warming resumed in the 1970s, and became marked in the 1980s. Here in Canada, we have had a general tendency toward warmer springs, with some very mild winters and hot, dry summers. But there is nothing simple about the warming, which leads to the second primary difficulty in the policy context: the underlying climatic trend is often obscured in any given region or country by short-term fluctuations. These receive wide media comment, and influence political judgment. It will remain difficult to overcome this confusion.

In passing, let me say that part of the short-term variability visible in these records derives from the fact that both the atmosphere and the oceans are to some extent regions of chaos, in the technical, mathematical sense. Another part of the variability arises from long-term interactions between these two regions. The oceans are enormous sinks for heat, their bottom waters being anchored near 2°C in all latitudes, as they have been for millions of years. This fact alone means that they may retard the greenhouse warming. And the great Pacific oscillations known as El Niño events affect the record. We are slowly learning how to cope with these realizations.

A second near-certainty is that global pollution is affecting the chemistry of the atmosphere. We have been monitoring carbon dioxide since the 1960s, and its upward global thrust,

at about 4 percent per decade, is now well established. Its concentration will, at present rates, double in the next century. Moreover, we can dig up samples from the ancient glacial ice of Greenland or Antarctica and determine the gas's past concentrations from bubbles of air trapped in the ice. A boring by Soviet scientists at Vostok, their station in central Antarctica, has shown (according to interpretations by French and Swiss glaciologists) that carbon dioxide and global air temperature have varied in concert for at least 160,000 years; high CO_2 has accompanied high temperatures, and the reverse. The borings do not say which is cause and which effect, but they support the idea that the greenhouse effect is a dominant factor in climatic control and was so before man became such an intrusive animal.

Other gases show rapid increases. Methane, for example, slumbered along at 700 parts per billion of the atmosphere from 3,000 until 200 years ago. It has since shot up to 1,700 parts per billion, and is increasing at 1 percent per annum. Increases are also observed in the synthetic chlorofluorocarbons, in spite of efforts to control their manufacture, and in nitrous oxide. Ozone, another greenhouse gas, is being affected by chemical pollution of the stratosphere, and may actually be decreasing at those levels. The net effect is that rising carbon dioxide concentrations are expected to contribute only about half the warming due to the augmented greenhouse effect. All the increases together may be the equivalent of a doubled carbon dioxide level as early as 2030, which is only 40 years from now (Rasmussen and Khalil 1986)!

To summarize to this point, two conclusions emerge. The first is that although major uncertainties affect the theoretical models that embolden us to predict the future, the observa-

tional record offers strong confirmation that a warming is already in progress, at a rate consistent with the more conservative greenhouse theories. The second is that there is much more uncertainty regarding the rate at which the human economy will continue to release carbon dioxide and the synthetic pollutants. Economic scenarios from the think-tanks — such as Oak Ridge, Resources for the Future, and the Beijer Institute — offer only very broad bands of possible values (Commonwealth Secretariat 1989).

Science and Global Warming

What, then, can be said about the two most obvious areas of direct greenhouse effects: the impact on the sea level, and the response of living organisms such as trees, crops, and marine resources? Both effects are much more difficult to predict than the greenhouse warming itself.

The sea level is obviously hard to measure because of the complicated influence of waves and tides. Tide-gauge records from around the world converge on an international clearing house at Bidston, in England. Close examination of these and other records suggests that the sea level may have risen worldwide by 10 to 15 centimeters in the past century, and that it is still rising. But the sea — which is not a perfectly level surface, even when waves and tides are stilled — responds to a number of factors. If glaciers melt, the sea level rises eustatically — that is, uniformly over the globe. If the ocean waters warm up, they may expand, and again the sea level rises, though not necessarily uniformly. And crustal movements may raise or lower the land relative to the sea, as has been happening along the Atlantic Coast of Canada and the United States

(the land is sinking). To predict the consequences of a greenhouse warming on such a complex system is difficult, to say the least.

Two eminent Canadian authorities have recently looked at this question, and have come up with different answers. Bob Stewart (1989) of the University of Victoria (and previously Chairman of the Alberta Research Council), doubts whether a general rise of the sea level can be disentangled from the effect of crustal movements, and concludes that any future sea-level rise is likely to be small, and unevenly distributed. Dick Peltier and A.M. Tushingham (1989) of the University of Toronto, on the other hand, find evidence for a present-day rise of the sea level at a global average of 2.4 millimeters per year, and allow for an acceleration in the future. A Commonwealth group convened to examine this question in 1988 used estimates by Tom Wigley of the University of East Anglia, and concluded that in the next 50 years the sea level might rise between 5 and 55 centimeters (Commonwealth Secretariat 1989). Among the expert groups you will find few who take seriously the suggestion that parts of the Antarctic glacial ice might soon slip into the sea and melt, raising sea levels by as much as 5 meters.

These groups do not really see Manhattan at risk. But rises of the kind visualized by the Commonwealth group, of the order of a half to one meter, are bad news for the inhabitants of the world's great deltas, such as the Nile, Mekong, and Ganges, who live at sea level, and whose homes and crops and even lives are even now at the mercy of high tides and storm surges. Our own Mackenzie Delta, the Fraser Delta, and the coastline of Prince Edward Island are at risk. Experts tend to make dull predictions, but see the real hazards more clearly than do the doomsayers.

Visualizing, or quantitatively estimating, the impact of the greenhouse warming on living organisms and, hence, on farming, fishing, and forestry, is even harder. This is because plants and animals are both vulnerable and adaptable to environmental change. Their genetic makeup imparts these qualities, and to some extent experience may also do so, especially in the human case. We know about these qualities only in an imperfect way. Moreover, we have no valid theory of ecosystem response to climatic change. We have to rely largely on empirical work, and have not yet got very far, though much is being done to mend matters.

Good work has been done, however, on the effect of the expected warming on agriculture, including on the economy of Canada's Prairie provinces. A group at the International Institute for Applied Systems Analysis in Austria (IIASA) led by Martin Parry of the University of Birmingham has coordinated this work, to which Canadian economists and agricultural scientists have contributed (Parry et al. 1988). As might be expected, there is serious concern about the effects on grain production, irrigation demand, and water supply due to the warming and drying forecast for inland North America by several of the models.

There is also work under way, notably in the federal Forestry Department, and in certain European countries, on forest impacts. In the case of Canada's boreal forest, large areas of productive forest are expected to be out of equilibrium with the climate in the next half-century, and to be subject to greater fire hazard and perhaps pest attack. The 1980s have given a grim confirmation of these changes: warm and dry seasons have permitted huge fire losses.

The fisheries, too, will be subject to disturbance, though recent economic and political hazards have overshadowed the

climatic factor. Canadian marine scientists are alert to the need to get on top of the question. They work closely with the atmospheric scientists on the joint aspects of the question, but the specific problem of the fisheries, inland as well as at sea, is theirs alone. Recent federal policy has not always been helpful in this area of science. Uncertainties still abound, and need long-term planning of an adequate Canadian and world response.

I have been deliberately frank in this brief review about the uncertainties that surround the prediction of environmental futures. I would advise everyone to be suspicious of dogmatic statements and flaming headlines in this area. At the same time, however, I have no doubt that the greenhouse effect is unquestionably real, and is likely to increase in magnitude. But precisely how much, how far, and how fast it will change things is still uncertain. I regard it as the central environmental issue of our times, relying as much on my instincts as on my appraisal of research. The effect is inescapably global, and can be rationally handled only if we act in concert with other countries. Yet this action will have to go forward in the face of uncertainties that will only slowly yield to the massive research effort now being mounted — and to experience, as we watch the temperatures rise (White 1989).

I am frankly startled by the way this issue has suddenly leapt into prominence, and been accepted by industry and government. In some ways the statespersons — for example, Mrs. Thatcher and President Mitterand — are now out ahead of the scientists. Those of us who were vainly urging action ten years ago are now faced with demands for action programs that we find it quite hard to design. Consider, for example, the findings of the 1988 World Conference on the Changing Atmo-

sphere, sponsored by the Canadian government (World Conference 1988). It has been astonishingly influential. The recommendation that fossil fuel consumption be reduced by 20 percent from 1988 levels by 2005 has been widely used as a base for proposed action programs designed by utilities, provincial, municipal, and federal government groups, and by corporations around the world. The Conference's views on how to get Third World participation have been less effective, but have also drawn wide comment. The view that control of fossil fuel use is the key to action programs needs to be counterbalanced, as stressed at the Conference, by a realization that control of the other greenhouse gases is equally important — and may be very hard to achieve.

Uncertainty and Action

I will not go into the questions of economic and political responses any further, since I was asked to concentrate on the limits of science. So I shall conclude with an answer to a crucial question: does the level of certainty about the greenhouse warming justify the action now being planned?

I think it does. But I also think the uncertainties should lead us to be cautious. Like most older people, I prefer cost-effective measures to those based on grand gestures. My views are that: (1) there is enough evidence that a global warming is in progress that we should assume for planning purposes that the greenhouse effect is already in progress, even if the observations do not prove it beyond reasonable doubt; (2) observations will give a firm answer about the greenhouse within five to ten years; (3) there is some evidence that nature prefers the less dramatic model results to the more exuberant; (4) climatic

monitoring aimed at demonstrating the reality of global warming, and of impacts in the key areas, must be given the highest priority; (5) more generally, environmental monitoring needs far more emphasis in the allocation of resources; (6) modelling must be pressed further, so as to remove as many doubts as possible; and (7) we must constantly seek international consensus as to the appropriateness of proposed actions, and do everything possible to assist concerted action to contain the situation.

Governments and corporations are used to such situations. Uncertainties abound in every aspect of economic and social policy. I recall Michael Harrington's saying that the more certain governments are of their facts, the more likely they are to make the wrong decision. But this is the first time in my recollection that governments and corporations have been faced worldwide with a public consensus that action must be taken to ensure and secure the environmental future. After years of skepticism, public and governmental opinion has suddenly raced ahead of elderly skeptics like myself. I hope that the new galvanic approach will get results.

I am often asked: how can you be so sure of the long-term future, when weather forecasts go wrong in under 24 hours? The answer is that I am not sure. Forecasts have improved. But weather responds to what I earlier called chaos, whereas climate — the statistics of weather — probably is predictable and nonchaotic. When I meet a businessman or an economist who says his/her predictions over the next half-century are better and more securely based than mine, I will back off. Meanwhile, I have no doubt that our best bet is to prepare for a greenhouse future.

Let me close on a personal note. In this paper, I have tried to be objective about the uncertainties in the environmental

sciences, and I have tried to address the legitimate concerns of business and government. But I must make clear that my own anxieties about this question arise from a quite different set of personal attitudes. I am a naturalist. I care deeply for the welfare of the planet, not because it is our home, but because it is what it is: the marvelous, beautiful, and staggering end-product of millennia — of eras — of natural and biological evolution. I have a strong bias in favor of protective action because of this desire to bring to an end what some have called "the rape of the earth." I hope that the actions we now take will serve, not only to enrich our own futures, but to let the planet go about its own dispassionate but superb business.

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Technology, Business, and Leadership in a More Environmentally Conscious Era

Norman R. Ball

To complement Kenneth Hare's focus on science and the environment, this paper examines some of the basic relationships between technology and the environmental challenge. It explores these connections in relation to three broad themes and by discussing briefly some examples of past dynamics where technology and environmental issues have crossed paths, often in unexpected ways.

The first theme is that of coming to grips with the differences between revolution and change. This is essential, since we are said to be entering a green revolution that, in turn, is but one of several other concurrent technological revolutions.

The second theme is that of deriving some lessons from previous historical examples of major technological change. These lessons include the need for intellectual openness, the need to understand and use the limits of science and technology, and the need to appreciate when science is leading, rather than following, technology.

Finally, the paper examines where we must ultimately look for leadership, given the dynamics of technology and the

environment. It concludes that, ultimately, more of the leadership must come from business itself.

Revolution and Change: Real Revolution or Inflated Rhetoric?

The computer is now a household product as well as a basic office, industrial, and research tool. Computers, and even more ubiquitously, microprocessors have so invaded daily life that it seems incredible to learn that the computer pioneers "had no glimmering of how thoroughly the computer would permeate modern life. The computer's inventors saw a market restricted to a few scientific, military, or large-scale business applications,"[1] and in the late 1940s and early 1950s leading experts in Britain and the United States predicted that fewer than ten electronic digital computers would meet their combined needs![2] For them, the computer "was akin to a wind tunnel: a vital and necessary piece of apparatus, but one whose expense and size limited it to a few installations."[3] Some other modern technological revolutions have been attached to the wildest imaginable optimism, such as nuclear power ushering in an age of electricity too cheap to meter. Misunderstanding

1 Paul Ceruzzi, "An Unforeseen Revolution: Computers and Expectations, 1935–1985," in *Imagining Tomorrow: History, Technology and the American Future*, edited by Joseph J. Corn (Cambridge, Mass.: MIT Press, 1987), p. 189. The collection of essays in this book is an excellent study of the expectations, confusion, and patterns of belief associated with a number of late 19th and 20th century technological revolutions.

2 Ibid., pp. 189–190.

3 Ibid. p. 189.

and an inability to predict impact seems to characterize most modern technological revolutions.

We are now in the midst of a revolution more fundamental and far-reaching than that of the computer. In addition to such rapid, ongoing technological change, we have also entered a period of rapid change in publicly expressed values. Fear for the future of humanity, questions about obvious resource depletion, greater knowledge of global suffering, awareness of abuses directed toward a planet no longer seen as capable of being an oasis of health in a sea of garbage have all helped to create the "green revolution."

As with any momentous change, the green revolution will have many repercussions, and the time to respond and plan is now. But if society so underestimated computers, and has been so far off the mark in predicting the specifics and contours of other fundamental revolutions, what hope is there for meaningful insight as a guide to future actions in the current situation? There are no easy answers, but not to search is an unacceptable response. Moreover, there are both lessons to be learned and focal points for reflection to be found in the past.

One is entitled to ask whether "revolution" means anything significant or whether it is merely another example of the current tendency to overuse a word until it has no real meaning. Growing references to revolution reflect both profound change and confusion. In Canada, technological revolutions are often tinged with both envy and fear — envy that someone else seems to have started them or to be ahead, and fear that we may be left behind economically unless we catch up in the next one. While such revolutions may have political components or impacts, they are not revolutions in the traditional political sense. But they are revolutions nonetheless, and must be understood as such.

In a classic study, Crane Brinton portrays "revolution," with its wide range of meanings and uses, as one of the "looser words" in the English language.[4] The sense of disruption, often violent and with consequent damage, underlies many meanings of revolution. Although revolutions need not be violent, the idea of change at such an accelerated pace that the participants are unable to adapt or cope comfortably is at the heart of events that merit the descriptor "revolutionary."

A single revolution is generally disconcerting enough, but the past several decades have seen widespread, ongoing multiple revolutions of two distinct types. The first and most noticeable is the essentially technological revolution, such as the computer revolution or the changes in manufacturing associated with statistical quality-control methods and just-in-time inventory-control methods in industry. The second type is a change in values such as that leading to increasing concerns over environmental matters. The combination of very significant shifts in values and technology has led to discomfort and confusion and, in many cases, to loss of confidence. While it is difficult to accept the view that humanity faces almost inevitable extinction, the very existence and credence attached to this view in some areas underscores the extent of the physical and psychological problems of the day. Thus, a period of profound change has started, but where is it going?

One of the most interesting, and consistent, features of past periods of significant or revolutionary technological change is the fact that the varied changes may be roughly grouped into two very distinct phases.

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4 Crane Brinton, *The Anatomy of Revolution*, rev. and exp. ed. (New York: Vintage Books, 1965), p. 3.

In the first phase, the new technology is used in old ways to do old jobs. For example, the automobile, driven by an internal combustion engine, was seen purely as a faster, smaller, and cleaner replacement for slow, cumbersome wagons and buggies pulled by horses that were polluting cities with manure and urine. These same horse-drawn conveyances also created terrible traffic jams, which hindered the progress of trade and raised the cost of doing business. The engine was put up front, where a horse would go, there were no thoughts of licensing drivers, and the conveyance was naturally called a "horseless carriage."

In the second phase, the new technology moves in ways that the pioneers could not have foreseen fully. In North America, the automobile, once regarded as safer than horses — which could become frightened and run away — became the largest single cause of death in certain age groups. The automobile reconfigured working and living patterns. It allowed large numbers of people to live ever-increasing distances from their place of work, and to spend far more time getting to and from work than would have been imaginable or acceptable in an era of slower, horse-drawn transportation. The automobile also introduced, or became part of, monumental pollution problems. Computers and microprocessors also exhibit the same the same pattern. Visions of small numbers of large, limited-use machines have been replaced by the reality not merely of home computers but of microprocessors at the heart of automobile ignition systems, airplane navigation systems, timers for home ovens, and home security systems whose improper usage and malfunctions are becoming a major nuisance for many urban police departments.

The element of unpredictability sounds a cautionary note to those who would like to travel on automatic pilot through

the uncharted territory of revolutionary change. It is not possible to map out the entire course of revolutionary change well in advance of making any other decisions. Nonetheless, there are valuable lessons and insights to be gained from understanding revolutionary change. There is neither reason nor wisdom in facing the new realities of environmental consciousness with a sense of despair.

Lessons of Technological Change

The history of technology suggests three basic lessons that are applicable to environmental issues. The first is the need for openness in the face of uncertainty. The second is the need to understand and to use the limitations of science and technology. And the third is the need to appreciate the problems of choosing between leading and following in the relationships between science and technology.

A Time for Openness in the Face of Uncertainty

Tempting as it may seem, a revolution is not the time for digging trenches or erecting barriers. Rather, it is a time for questioning, reflection, and communication between different perspectives, disciplines, professions, outlooks, backgrounds, interests, and concerns. Unfortunately, clear and original thought, openness, and intellectual honesty are often the earliest casualties of any revolution. The closed-thought mode, the herd mentality, the circular gathering of wagon trains to keep new ideas at bay is at one level an understandable defensiveness. But it is the wrong response during revolutionary change such as that posed by the new environmental

consciousness. If one accepts the idea that it is not possible to predict with absolute certainty the direction of change, then it becomes hard to condone inflexibility, narrowness of view, and counsel from only a limited circle of sources.

Understanding and Using the Limitations of Science and Engineering

In accepting the need for flexibility and the inevitability of uncertainty, it is vitally important that a common misunderstanding of the nature of science and engineering not lead to the erroneous belief that it is time to discard science. It not science itself that should be discarded, but the often-facile notions of science as the final arbiter of all reality and a certain guide to all future actions if only one could find "good" science.

A fruitful way of looking at science is as a human invention, not something preordained as the ultimate and final guide to reality. In many respects, the body of scientific knowledge may be described as the answerable responses to the questions we care to ask. In this view, limitations in mind-set, imagination, or technology restrict science — changes in any one of the three have the potential to change the content of scientific knowledge. In a similar vein, it is useful to think of technology not only as an aid to satisfying wants and needs but also as something that usually does what it is told. One should not forget the element of success, but one also needs to remember that technology often, perhaps always, does more than one asks, and it is this element of surprise that is the cause of considerable difficulty. Often, the surprise element is both real, in terms of genuine inability to see or foresee, as well as imagined, in that the problems were ones that society at the

time chose, consciously or unconsciously, to ignore even though they could be seen by those willing to see them.

Preoccupation with science as the source of certainty, rather than as a limited answer to selected questions, brings with it a tendency to distrust or downplay science at the very time one needs a broader view of its mandate and areas of study.

Both science and technology respect and express values. They help us do, or understand, things we feel are important. As values change, science and technology can be expected to change in terms of areas of activity and emphasis. There is little to be gained by feeling guilty because we did not do something 20 years ago when, in fact, either the knowledge or widely accepted cultural values did not make that an appropriate response or activity. It is far better to see the link between cultural values, expectations, and perceptions on the one hand, and the ways in which these are expressed on the other hand through science, technology, and engineering. For only then does it become apparent that the current significant shift in values is fully compatible with a science- and technology-based culture.

In Canada and many other Western countries, there is a tendency to explain technological changes or advances as the result of new science. This notion is easy to present in classrooms, museums, documentary films, and other vehicles of popular culture. In some cases, it also has advantages for those seeking research funds. There is only one problem with this simple cause-and-effect relationship, which more than outweighs its convenience and ease of understanding: it is often wrong at worst and misleadingly simplistic at best.

Science and technology, or science and engineering, should not be seen as a parade in which one of them always

stays in the lead. That is the wrong imagery. It is better to think about a friendly and confident couple skating on a vast lake. Sometimes they will be side by side but close, with each helping and urging the other on. At other times they will be side by side but far apart, with little communication. Then, one will glide directly ahead of the other; later, the positions will reverse. A detached observer with a long time frame will see no clear pattern of leadership or domination, but will sense a closeness or partnership and mutual strengthening.

This view is a far cry from the dominant-submissive model, which has technology forever following and beholden to science. But there can be no doubt about the changing patterns of leadership. Consider thermodynamics, that oft-reviled nemesis of science and engineering undergraduates. Thermodynamics originated as an after-the-fact science to explain, first, why steam engines actually work and, second, why a number of very ingenious and elegant things done by steam engine designers actually enhanced performance. Thermodynamics skated along behind steam engine designers, eventually caught up and provided valuable insights into what had been achieved, and then glided ahead to provide guidance for further design solutions. Thermodynamics has proven to be a monumentally useful science with numerous applications, but there are still areas of engine design that work, but that are not explained in terms of thermodynamics.

The more simplistic view of science as the certain, complete leader brings with it a tendency toward anti-science. Disenchantment with our current predicament is readily translated into disenchantment with science — the "we need less science and technology" cry, rather than the more appropriate statement that "we need science and technology directed by and toward new priorities."

Uncertainty and the acceptance that there are boundaries of knowledge are at the core of science. Science is based on asking restricted questions and making certain observations, not on asking every question imaginable or making every observation imaginable. Science also depends on the associated technology for doing things such as gathering and processing information. In short, new instruments bring about new science.

The element of uncertainty and the acceptance of restrictions are not at the core of public perceptions of science. They are, however, fundamental to engineering, and are one of the reasons why science, technology, and engineering have so frequently done for us what we have asked.

Uncertainty is enshrined in engineering through over-engineering, or the use of safety factors. Consider the case of a simple bridge for vehicular traffic. One could calculate the size of beam required to carry a predicted load, assuming that the beam is made of uniform material manufactured under ideal circumstances and installed perfectly with no damage during transportation to the site. In actual fact, materials suffer from some lack of uniformity, installation may be less than perfect, and the beam may have suffered minor, imperceptible damage while being loaded onto the truck at the steel mill. To compensate for these very real possibilities, the beam is designed to be larger and stronger than that determined by theory in a perfect world. Similarly, engineers build for an expected or legal load limit, while recognizing full well that, intentionally or otherwise, there will be vehicles or combinations of vehicles on the bridge at a given time that exceed the legal load. So an additional safety factor is built into the bridge, and this is why bridges rarely fail.

What has happened in the case of bridge design is that uncertainty has been as much a guiding principle as certainty. In simple operational terms, it means that the guiding procedure is to build for more-than-known imperfections and existing ranges of activities. The philosophy is that, when in doubt, design for the worst not the best or optimal conditions.

One factor in the emergence of environmental awareness is the staggering growth in the past several decades of tools for science. Many current concerns about pollution and environmental degradation depend in part on things that could not have been measured 20 or 30 years ago. We have been given new capabilities and new ways of knowing. Perhaps an even more fundamental shift in science is that it has taken on a new or larger time frame and has become even more concerned with interrelationships.

Toxicology, epidemiology, and ecology, for example, are important foundations of the new environmental consciousness; they all deal with complex interrelationships, many covering an extended time period. There is a strong danger that the relative newness of these fields, and the public and political failure to understand past ways of dealing with uncertainty, may lead to an unstated policy of acting on *underestimated* risk, rather than on traditional overestimated risk.

Too many people fail to appreciate how honestly we have faced up to risk and uncertainty in many areas in the past. They do not appreciate that we have adopted some very good mechanisms and coped very well when we have chosen to do so. In the face of current, seemingly insurmountable problems, there is the danger that some will say "we have always had big risks in the past, and therefore we have to learn to live with uncertainty." While this is true, it is dangerous when coupled

with the recommendation that we carry on without change until we know more about the sciences relating to what is happening. If this is allowed to happen, then we will have turned our backs on one of the great lessons to be learned from the beneficial side of our past and current relationship with science, technology, and engineering.

Choosing between Leading and Following

Survival during a period of rapid change is an extremely complex issue and there are no money-back guarantees. Nonetheless, leaders, or those who are able to bring about or strongly influence the direction of change, tend to have a higher survival rate. There are many examples of pioneers who were supposedly ahead of their time and suffered for it. But there are far more cases of pioneers who gained advantages during periods of intense change, which allowed them to continue as leaders during subsequent periods of relative stability or continuing change.

There are many factors involved in maintaining leadership and the ability to make choices, rather than in following the choices of others. One that appears frequently is the ability to fundamentally rethink a problem. When analyzed carefully, seemingly fresh solutions often emerge as little more than band-aids or patches on a limited or outmoded process or system. Fundamental rethinking is quite rare and often it is the key to significant leadership opportunities.

Consider, for example, the case of stringent emissions standards for automobile engines. Most automobile companies tackled the problem after combustion had taken place by dealing with the exhaust. Catalytic converters reacted with

unacceptable exhaust gases to reduce emissions. Without the catalytic converter, exhaust emissions would be unacceptably high. While workable, converters alone did nothing to alter the existing deficiencies of internal combustion engines. However, at least one major automobile manufacturer, Honda, took a different approach by turning to the source of the exhaust gases — namely, the combustion chamber. A newly designed combustion chamber and cylinder head allowed standards of the late 1970s and early 1980s to be met without the added catalytic converter used by most other manufacturers. Changing emissions standards and the inclusion of new gases in the standards eventually forced Honda to adopt the catalytic converter as well. But the research experience in rethinking engine layout produced significant design knowledge and gave Honda a lead in other changes as all automobile manufacturers sought greater power, economy, and efficiency within the restrictions imposed by emissions regulations.

For a second case, consider the North American steel industry. In the 1970s and 1980s, increasing offshore competition, often outdated equipment, sometimes inappropriate union regulations or inattentive and unimaginative management, as well as customer demands for higher quality conspired to create crises within the industry. In Hamilton, Stelco Inc. wanted to install a new rolling mill to increase both quality and competitiveness in a growing market segment. However, the company's board of directors turned down the initial plans because the proposed state-of-the-art mill would have been so expensive to build and maintain that it could not have competed with offshore products. Only then did the designers begin to rethink the project in a serious, fundamental way. As a result, the rolling process — which had remained essentially

unchanged since the early 20th century — was revolutionized with the invention of the Stelco Coil Box. This invention reduced the length of rolling mills, reduced power consumption, increased the consistency and quality of the steel, and provided Stelco with a valuable piece of proprietary technology that it has sold worldwide. Without such radical rethinking, market share, continuing sales opportunities, and environmental improvement would have been lost.

But exhortations to do better and timely lessons from the past still leave fundamental questions unanswered. Who should lead? How should leadership be encouraged or forced?

Where Do We Look for Leadership?

In the postwar era, Canada has moved toward increasingly higher levels of government involvement in many facets of business and daily life. In a society favoring and benefiting in many ways from such a relationship, it has been logical to believe that government plays the dominant and pioneering role in controlling business and initiating adaptation to changing technology or expectations. But this is too stereotypical a view about what has actually happened in particular sectors.

Consider, for example, that at one time electricity was regarded as a new and dangerous technology. Electrical equipment manufacturers and electric power producers saw that it was in their best interests to make the new technology much safer and more easily used by consumers. They thus played a pioneering role in the introduction of greater safety and eventual standardization through the work of agencies such as the privately run Canadian Standards Association.

Similarly, business provided strong leadership during the earliest attempts to introduce better water supply and sewage systems, because it understood the consequences of the failure to make necessary improvements. A generally unhealthy work force, inadequate protection in the event of fires, and too little water for industrial processes all reduced the potential of business to earn profits. Business was also enthusiastic about improved transportation and power systems.

Indeed, business has often been more enthusiastic about reforms of this nature than have politicians. Operationally, good business usually has a longer time perspective than has government, which tends to think more in terms of winning the next election. Given a choice, business would rather face a state of certainty regarding important variables than uncertainty and unpredictability. On the other hand, evidence suggests that there is often more political appeal in allowing a problem to fester for a long time, followed by a short burst of apparent activity and commitment, than in slow, concerted, effective action.

Moreover, business tends to have less complicated and more achievable goals than does government. This is potentially a very strong argument in favor of relying more on business to take a leadership role in environmental problem solving. But it depends on whether one views business as meriting the confidence needed to allow it to help set environmental goals. If one considers that a major task of government is to get re-elected, and to keep a wide and extremely varied constituency happy, then its job, like fighting sin, can never be finished. There is always another election on the horizon, and too much done for this election might make it harder to do as much for the next.

Because it is more likely to have clearly defined and workable goals, and because it is more flexible in choosing time lines, business is also more likely to be able to respond quickly to surprises. And surprises will be in no short supply in the coming years. Government, on the other hand, is often far removed from either real or operational knowledge and lacking in the ability to make quick decisions. Thus, it is more likely to induce wild swings of the pendulum than the damping motion needed to restore stability.

If one recognizes that it takes an inordinately long time for environmental legislation to be passed and for the courts to deal — rather ineffectively, at that — with those who violate environmental regulations, then the limits of governmental leadership are clear. At a time when the awareness of new environmental hazards and the need for quick, decisive action is increasing rapidly, it becomes rather discouraging — almost to the point of black humor — to realize that government legislation and court enforcement will do little more than fall further and further behind economic and environmental reality. It appears profoundly illogical to rely on a such a slow and increasingly ineffective system. There seems to be every incentive to find alternate ways of addressing the problem. And there is little choice but to consider creating an operating environment in which it is clearly in the interests of business to become the leader in setting and reaching higher levels of environmental responsibility.

Some critics of business might claim that this approach is unacceptably radical — that it is a pro-business sop. But I prefer to view it as an example of rethinking fundamentals. It could only be achieved if business were to rethink its attitude toward corporate responsibility and its own keys to longevity.

This has already started, in fact, as an increasing number of firms realize that it is easier to design to stay ahead of somewhat unpredictable environmental regulations than to play a constant catch-up game. Responsible business leaders are also beginning to understand that the legacy of lengthy and debilitating lawsuits is not what one should leave behind after retirement. This attitude must penetrate every level of the company; in many, that will be extremely difficult.

Giving business a clear incentive to set and meet realistic environmental goals recognizes the strengths and weaknesses of both business and government. It also recognizes that there is nothing inherently wrong with rewarding good behavior and punishing the bad.

John Baglin, one of the pioneers in the emerging field of superconductors, has observed: "The question is not 'How can we take this material and do something everyone has wanted to do?' but 'How can we do something that has not yet been imagined?' "[5] The same question must be asked about relations between government and industry as all of humanity faces the environmental challenge.

5 As quoted in Michael D. Lemonick et al., "Superconductors! The Startling Breakthrough that Could Change Our World," in *The Materials Revolution*, edited by Tom Forester (Cambridge, Mass.: MIT Press, 1988), p. 35.

Environmental Policy Issues: Market Failure in the Third Phase of Economic Activity

Arlon R. Tussing

"Environmental" problems and environmental policy issues mainly concern natural or man-made resources whose allocation and management are *not* effectively governed by the mainstream institutions of liberal capitalism.[1] To a large extent, these issues are special — and specially troublesome — because and to the extent that *property rights are undefined* (or, perhaps, undefinable) with respect to specific resource stocks, or because *markets are lacking* (or impaired) with respect to the services or products of such resources. Environmental policy issues as a class are thus typically concerned with *assets whose uses are unpriced or underpriced*, either because the resources are owned in common (by "everybody" or "nobody"), or because the prices for their use are not market determined. Elementary economic principles predict that such resources, such as the ability of the atmosphere to dispose of unwanted material byproducts of human activity, will be over-

1 These institutions include personal freedom and occupational mobility, markets, and, most importantly for purposes of this paper, property rights in the use of resources rights that are legally defined and protected, divisible, combinable, and freely transferable.

utilized and inefficiently allocated among competing uses (Fisher & Peterson 1976).

The Fundamentals: The Three Phases of Economic Activity

In this paper, I distinguish three "phases" of economic activity by analogy with three essential attributes of living organisms: (1) inputs of natural resources; (2) production or processing; and (3) disposal of wastes or residuals. In more cases than not, the most critical resources and resource services lacking workable property rights or effective markets — and those dominating concern about environmental issues — are those that are essential to the "third phase" of economic activity: the disposal of wastes or residuals.

As a general proposition, I argue that the most effective and efficient means of dealing with pollution, congestion, or other environmental ills center on creating property rights in and markets for the use of customarily "free" goods. There are also numerous opportunities for public authorities to establish prices for access to otherwise unpriced "public" goods, to adjust the prices regulated by those authorities to levels that approximately balance supply and demand, or to impose taxes[2] on various activities so that their prices reflect the environmental or "external" costs[3] such activities impose on

2 In some instances, the appropriate "tax" may be one with a negative value, thus taking the form of a "subsidy" — say, for recycling wastes rather than disposing of them.

3 An *external cost* associated with some transaction is a cost that direct parties to the transaction do not bear in the form of explicit outlays for equipment,...

parties other than their direct beneficiaries. This paper will focus largely, but not exclusively, on third-phase environmental issues — that is, on the various forms of pollution.

Essentials of Life: Nutrient Capture, Metabolism, and Excretion

Pollution as such is not an inherently immoral or unnatural activity. It is the elimination of pollution that needs to be recognized as a literally unnatural and unachievable goal.

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3 - cont'd.

...materials, or services. Instead, it is incurred by third parties who do not benefit. Likewise, an *external benefit* is a benefit that neither party to the transaction captures, but instead is conveyed on third parties who are not required to pay for it (Pigou 1920; Scitovsky 1954; Mishan 1971).

Highway congestion offers a familiar example of an external cost. As the number of cars attempting to use a given stretch of road increases, traffic slows and the carrying capacity of the road actually declines in terms of vehicles per hour. The delay that each added vehicle imposes on all others is thus an external cost of its using the road. Each driver incurs the normal ("internal" or "private") set of costs — monetary and otherwise — connected with each trip: vehicle depreciation, maintenance and fuel; plus his own time and aggravation. It is these costs that will influence whether or not he chooses to drive that car, on that road, and at that time. But no driver will be accountable for or likely be influenced by the external costs of his decision — including the additional delay and aggravation the presence of his car imposes on others.

Air pollution is another handy instance. The ability of the atmosphere to remove and dissipate various unwanted byproducts of industry, travel, and consumption is a valuable natural asset. But nature's capacity to provide these services and at the same time keep the air safe and pleasant to breathe is limited. In general, manufacturers and consumers alike incur appropriate supply costs for the durable and nondurable goods, labor, and purchased services they use, and have a corresponding incentive to control and minimize such costs. No such incentive exists, however, with respect to the external costs of air pollution: the unpleasantness and unhealthiness of smog, the human and material costs of acid rain, and the like. If people are permitted to use the waste-disposal capability of the atmosphere without charge, they will surely overuse it.

Pollution is simply a pejorative term for one class of processes that are inseparable from life itself — the discharge of "waste" materials and energy into the environment in exchange for other materials and energy forms that organisms must take from the environment in order to function, grow, and reproduce. Indeed, it is this process of exchange that is arguably the defining essence of life.[4] At some concentration, any met-

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The concept of externalities thus allows us to view many environmental policy challenges as problems of inappropriate prices or "market failure," in contrast with the situation that prevails in an idealized "normal" market, where all costs and benefits are "internalized." In normal markets, scarce and valuable goods command a price that limits the amount of those goods demanded by consumers; the same price constitutes an incentive for producers to make the right amount of supply available, and rations that supply to its highest uses. Untreated externalities, however, tend to sabotage these mechanisms and create a situation in which costs and benefits are not equal at the margin, and in which the market does not "clear" — that is, chronic shortages and/or surpluses are able to persist.

Unlimited and unpriced access to rush-hour freeways, for example, means that the total ("social") cost of adding another vehicle — the sum of "private" (internal) and external costs — will exceed the total benefits of adding that vehicle (all of which are captured by its operator). Typically, demand for such road access will exceed supply, and the road's effective capacity will be diminished (in terms of vehicles per hour) by each additional vehicle that tries to use it, as congestion prolongs the time each of them must spend to travel that piece of road.

Unlimited and unpriced rights to use the atmosphere as a waste-disposal facility likewise mean that the total ("social") costs, including both internal and external costs, imposed by additional emissions will exceed the social value of that access. Society's demand for the atmosphere's waste-disposal services will thus tend to exceed its ability to accept wastes without unacceptable environmental damage.

4 According to Barlow and Volk (1990):

Bernal (1951) has concluded that life is manifest only in the form of open systems. Lovelock and Margulis (1974) cite Bernal's definition in their own work: 'life is one member of the class of phenomena which are open or continuous reaction systems able to decrease their entropy at the expense of free energy taken from the environment and subsequently rejected in a degraded form.'

abolic residual becomes a poison to its producers. Thus, the mechanisms of waste disposal are inherently no less essential to life, and no less critical to survival of specific organisms, populations, or species than their access to those "nutrients" and forms of energy that constitute essential metabolic inputs.

Essentials of Industry: Resource Inputs, Processing, and Waste Disposal

Pollution is likewise an inevitable consequence of agriculture, manufacturing, and the countless spectrum of other activities associated with human technology. These undertakings embrace the same three phases as life itself: (1) the harvesting of energy and material inputs; (2) their processing and transformation; and (3) the return of energy and materials to nature in new forms. Civilization's economic endeavors simply swell and diversify the gross demand of our species for primary resources and the gross supply of residuals it must dispose of.[5] Like the carbon dioxide, excrement, and carrion generated by both pretechnical and modern man, troublesome wastes

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4 - *cont'd.*

Bertalanffey (1952, pp. 124–1250) also found thermodynamic openness to be an essential feature of life: 'From the standpoint of physics *the characteristic state in which we find the living organism can be defined by stating that it is not a closed system with respect to its surroundings but an open system which continually gives up matter from the outer world and takes in matter from it*, but which maintains itself in this continuous exchange in a steady state, or approaches such steady state in its variations in time' (*emphasis added*).

5 It should be noted that increases in income and product do not inevitably imply net increases in the volume of materials required by society or in the volume of residuals discarded. I elaborate on this point later.

are thus natural and inevitable corollaries of ingenuity and knowledge in the service of human wants.

While individual organisms may deposit their wastes on the land or discharge them into bodies of water or the air with seeming impunity, this is of course not true for large populations or groups of populations that share similar metabolic cycles and thus, in the aggregate, produce huge volumes of similarly toxic (to them) wastes. The net production of such wastes by the earth's total biomass nevertheless tends to converge toward zero, at least on a global average and over time, thus making possible the survival of populations and the continuity of life itself. Such an equilibrium has come into being only because evolution contrived a medley of species among whom the poisonous rejects of some have become the sustenance for others and vice versa.

Evolutionary adaptations to specifically human impacts on the environment have been numerous — and have included the emergence of new species and extinction of old ones, as well as modifications to others. Given the magnitude and speed of change, however, our species is unlikely to be satisfied with the pace or even the direction of such "blind" evolutionary adaptation. So long as growth and change in mankind's demand for material inputs and its productive activity are driven by human ingenuity, infused by human knowledge and insight, and motivated by a uniquely human compound of greed, altruism, idealism, and curiosity, it is reasonable to expect that society would apply a similarly weighty mix of intellectual resources and motivations to the management and disposal of residuals. Such a balance in either effort or performance among the three phases of economic activity does not, however, seem to be in evidence.

The Domain of Liberal Capitalism

Industrial man has been most spectacularly successful with respect to the first two phases of economic activity — primary extraction and processing — a performance that has totally confounded thinkers from Malthus (1798) to Meadows (1972), who, reasoning within a "finite-earth" paradigm, viewed the supply of material inputs as critical limits to human enterprise.[6] The necessary and sufficient foundations of this success have been the institutions of liberal capitalism: personal freedom and occupational mobility, markets, and property rights — legally protected, and divisible, combinable, and freely transferable.[7] These institutions have saturated capitalist democracies with those "optimizing" modes of thought and behavior that now characterize engineering and management in all branches of human activity, not limited expressly to profit-seeking activities.

The fact that net resource demand and the net "pollution" burden have each tended to approximate zero for all species together on a global level does not imply that humanity and its works can ever hope to have a zero net-pollution impact on the

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6 I have dealt elsewhere with the way in which enterprise and technical change steadily overcome the alleged "finiteness" of primary energy resources; similar principles govern the supply of foodstuffs, nonfuel minerals, and other resource-based inputs to production (see Tussing 1978; and Tussing & Van Vactor 1989).

7 Malthusian pessimism is still a plausibly credible perspective for the 1990s and beyond, but only to the extent that it counterposes global population forecasts to the global supply outlook for foodstuffs, fuels, and the other material requirements of civilization, and only to the extent that the global picture is dominated by the circumstances of nations that have not embraced liberal capitalism. There is no plausible scenario for the plannable future in which "shortages" of material inputs would constrain population levels or economic growth in North America, Western Europe, or the Eastern Rim of Asia.

earth. It does, however, show that no necessary fixed ratio exists between the real product and income of mankind (the volume of goods and services produced) — on either a total or per capita basis — and humanity's net demand on the environment for materials and energy, or the net burden of pollution that humanity imposes on the environment. The range of values this ratio ultimately takes is the combined effect of two technical parameters:

- *Internal efficiency* in specific commodity cycles, industries and economic sectors — the ratio of useful product in each to its gross inputs for raw materials and energy and the gross outputs of waste products.[8]
- *"Recycling"* links between different commodity cycles, industries, or sectors — the use of otherwise useless or troublesome byproducts of one activity as valuable inputs to another — a synergism that reduces both primary resource demand and the net volume of wastes to be disposed of, per unit of useful output.

The Thrust of Technology and Institutional Change

The thrust of profit-driven economic optimization and the momentum of contemporary technical change would both generally favor improvements to technical efficiency and greater recycling,[9] even if the direct impact of profit-seeking

8 The relevant wastes include those that occur in the primary production of raw materials and energy, in transport of intermediate and finished goods, in production proper, in final consumption, and in the deterioration and discard of durable goods.

9 Some of the reasons for this bias are set out in Tussing & Van Vactor (1989).

behavior, and the optimizing influence of markets, were confined to first- and second-phase activities. In the first place, those productive arrangements that reduce the amount (and therefore the cost) of space, materials, and energy per unit of value of goods produced tend to cause a comparable reduction in the volume of residuals per unit of value. Moreover, even if environmental-protection strategies remained largely of the "command-and-control" variety, third-phase activities would still be able to call on efficiently organized producing sectors and markets for their inputs of equipment, materials, and human services.

A further critical advantage of modern democracies in coping with third-phase problems is their openness and the resulting speed with which information is disseminated, and the incentives thereby imposed on elected officials and bureaucrats to "do something" about conditions the public perceives as intolerable.[10] The absence of viable property rights and workable markets with respect to third-phase resources nevertheless goes a long way toward explaining the contrast that exists between the ability of advanced economies to expand the production of goods, in terms of variety and quality as well as volume, and their performance in coping with such "bads" as congestion and pollution.

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10 It is ironic that many environmental activists and much of the public still see markets and profit-seeking enterprise as the main source of pollution and other environmental outrages, and seek remedies in the expansion of government authority. But the superiority of liberal market economies, even with respect to matters for which they do not rely on market mechanisms, is now obvious in the deadly severity (only now being disclosed) with which the Soviet Union and Eastern European countries have been poisoning their people through a huge variety of toxic discharges.

The Rationale for Markets as Tools of Resource Management

The concept that environmental problems involve market failure or incorrect pricing justifies searching for strategies and tactics for using market mechanisms wherever practical, in place of detailed prescriptions or proscriptions by government agencies regarding the activities of industry, households, and other human institutions. A market-oriented strategy for energy and the environment is thus one that minimizes intrusions upon the freedom of consumer choice, lets businessmen do what they do best, and reserves to government the roles that only it can play and discharge responsibly.

Such market strategies are thus likely to be more effective and efficient than technical prescriptions and proscriptions in achieving specific environmental-quality benefits, to the extent that they work with, not against, the prevailing currents of technical change — which favor internal efficiency and synergism — and with, not against, the motives that ordinarily drive decisions made by millions of consumers and producers.

Recognizing and Internalizing External Costs

To the extent the environmental (external) costs of various activities can be made explicit, so that producers, transporters, resellers, and consumers of fuels and energy can be made financially responsible for the burdens their decisions impose on others, the various parties will be spurred to apply the same kind of ingenuity and effort to minimizing those costs as they do with respect to the majority of first- and second-phase costs.

Using Markets to Protect the Environment

Emissions Charges and Related Subsidies[11]

Governments use general tax revenues to subsidize waste-disposal facilities and operations, and for after-the-fact abatement of harmful residuals more frequently than they employ taxes or charges on waste-producing activities or effluents to influence the behavior of polluters.

The idea that taxes or charges on harmful emissions into bodies of water can be used to control and ration access to natural waste-disposal facilities, and at the same time compensate society (or specific victims) for the costs of pollution, dates back at least to Pigou (1920). But the actual implementation of effluent charges became widespread only in the 1960s. Hahn (1989) offers a nonexhaustive overview of established systems of charges for water-borne effluents in four countries: France, West Germany, the Netherlands, and the United States.[12] Even where effluent charges are levied, more-

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11 Taxes and subsidies can be economically equivalent in principle as a means of dealing with environmental costs, though their distributional impact and thus their political appeal are likely to vary immensely.

12 Hahn has this to say about systems in the four countries:

On France:

> The French have had a system of effluent charges on water pollution in place since 1969. The system is primarily designed to raise revenues which are then used to help maintain or improve water quality. Though the application of charges is widespread, they are generally set at low levels. Moreover, charges are rarely based on actual performance....
>
> Charges now appear to be accepted as a way of doing business in France. They provide a significant source of revenues for water quality control. One of the keys to their initial success appears to have been the gradual...

over, they still tend to be directed mostly toward raising revenues that help finance remedial strategies. Few existing systems of charges were expressly established for the purpose of influencing the behavior of polluters or their customers, and such effects are indeed hard to demonstrate.

The establishment and protection of property rights has been the usual rule regarding land and other natural resources used in first-phase economic activities in pre-industrial and pre-market societies, as well as in modern capitalist democracies. On the whole these assets are ones that are relatively easy to appropriate and defend, and to partition and exchange. The institutions that have evolved to govern their use tend to reflect these qualities.

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12 - cont'd.

> ...introduction and raising of charges. Charges started at a very low level and were gradually raised to current levels. Moreover, the pollutants on which charges are levied has expanded considerably since the initial inception of the charge program.

On West Germany:

> The German system of effluent charges is very similar to the French system...[and] covers a wide range of pollutants, and the charges are used to cover administrative expenses for water quality management and to subsidize projects which improve water quality....While hard data are lacking, there is a general perception that the current system is helping to improve water quality.

On the Netherlands:

> The Netherlands has had a system of effluent charges in place since 1969, and the charges placed on effluent streams are among the highest....In general newer plants face more stringent regulation than older plants....[T]his is also a dominant theme in American regulation.

And on the United States:

> The United States has a modest system of user charges levied by utilities that process wastewater, encouraged by federal environmental regulations issued by the Environmental Protection Agency....The primary purpose for the charges is to revenues to help meet the revenue requirements of the treatment plants, which are highly subsidized by the federal government (Hahn, pp. 104–106).

Common Property and Privatization

The environmental and "conservation" policy dilemmas and controversies associated with first-phase extractive activities center on the management of external costs for resources that are not subject to "normal" property regimes because of their "common-property" features. The best-known instances concern "fugitive" resources and resource stocks, such as wildlife and fisheries, and underground oil and gas reserves.[13]

In the absence of specific statutory or contractual provisions to the contrary, Anglo-American common law typically subjected these resources to a "rule of capture," in which property rights are defined only for the resource product, and only after it has been harvested. Economic theory predicts that the marginal private (internal) return to the effort of each single enterprise extracting such a common-property resource will remain positive and thus continue to attract more effort, even after the marginal return to the efforts of participating enterprises as a group has fallen to zero or become negative. Regulatory regimes for such resources are largely attempts to overcome the obvious physical waste associated with the operation of the rule.

Remedies generally fall into two categories:

- *command-and-control regulation*, by which some public authority or trade group limits the amount of extractive effort and/or prescribes the equipment and techniques that may be used in extraction; and

13 The problem with oil and gas arises from the tendency of underground fluids to migrate from a position beneath the surface parcel owned (or leased) by one party toward a well that may be on property owned by others.

- *privatization and/or unitization*, in which ownership or other property rights are defined with respect to units of the resource, whose scope and scale are sufficiently wide that the operator will have the ability and the incentive to supply the optimum quantity of effort, choose the most efficient mix of technique and productive inputs, and thereby maximize the present value of the resource stock's life-cycle or perpetual productivity.

Not infrequently, a particular kind of resource may be free of "conservation" regulation in some jurisdictions, regulated by command-and-control measures in others, and by creation of novel configurations of property rights in still others. Regulatory measures to mitigate the waste that would otherwise attend the rule of capture in oil and gas fields whose control is fragmented among several operators varies, for example, between California and U.S. federal offshore lands (where voluntary unitization is permitted but no mandatory conseva-tion measures are in effect), Texas (which relies mainly on command-and-control regulation — particularly well-spacing rules and production quotas for individual wells), and states such as Alaska and New Mexico (in which field unitization is mandatory).[14]

Fishing of similar resource stocks is, likewise, largely unregulated in some jurisdictions, and regulated in others (with varying degrees of physical success and economic inefficiency) under command-and-control rules that center on seasonal and gear limitations. Some jurisdictions recognize property interests in defined stocks or access to them (as in

14 Among the three systems, mandatory unitization best fosters economically efficient oil or gas extraction because it simulates the incentives.

the case on certain salmon and trout rivers of the United Kingdom and Norway); others have created a kind of tenancy-in-common property interest in harvesting certain fish stocks, in the form of transferable "limited entry" permits.

The diversity of existing institutions for managing publicly owned, fugitive, or common-property resources is immense, even in the United States and Canada alone. A survey comparing such arrangements with respect to their effectiveness, undesired side-effects, and the facility with which they accommodate competing resource uses, is likely to yield useful lessons regarding the feasibility of analogous arrangements that might be contemplated for managing of third-phase environmental assets.

Management by Private Parties versus Government

The most dramatic horror stories regarding economically wasteful management and environmental despoliation tend to be associated with publicly owned resources or the manner of their disposition to the private sector. But government ownership or management as such does not compel inefficiency.[15]

15 If an agency's objectives for managing public property are clearly stated in such a way that its performance can be quantified, and especially where its objectives closely resemble those that drive private owners of similar properties, there is no certainty that privatization would improve performance. The paramount objective of several U.S. states with respect to leasing or sale of minerals is essentially "profit maximization" — to optimize the present value of leasing or sales revenues over the life of the resource stock. In some cases the responsible agencies have records at least as good on the average, and in some cases (Alaska's oil and gas leasing, for example) better, than the performance of the biggest private landowners — for example, railroad companies).

Nor is there reason to presume government agencies are inherently inferior to that of private entities in the rationality with which they assess tradeoffs...

It undoubtedly helps for resource rights to be offered in a competitive market, by means of an impartial disposal arrangement such as an auction, which is expressly designed to determine and obtain full market value. Awarding rights to those parties that value them highest also leaves the greatest latitude for protection of the noncommercial values associated with, and presumably impaired or threatened by, commercial development. For these reasons, all financially competent parties, including brokers and speculators, should be eligible to tender offers. The market value of rights so granted are highest where they are as clearly defined and secure as those conveyed in otherwise similar contracts between private parties; specifically, rights and obligations should be fully defined in contracts that are equally binding on both parties — and not subject to unilateral abrogation or amendment.

Efficient allocation and employment of resource rights also demands that they be freely divisible and combinable, and salable and assignable, in whole or in part, permanently or

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> ...among competing resource-development objectives, provided the expected costs and benefits attached to the alternatives can be quantified in terms of dollars or some other common measure.
>
> The greater sensitivity of government agencies to public concerns that are not readily measured in dollars may actually make them more acceptable, and thus more effective, than private enterprise as mediators of conflicts between commercial resource uses and noncommercial values. Here particularly, the measurable economic benefits that are consistent with a given set of noncommercial constraints, or attainment of specified noncommercial goals, are likely to be maximized only to the extent that such constraints and goals are clearly specified in qualitative or quantitative terms, and in terms of either means or performance. High bids will also be higher to the extent that bidders assume that the winner will be able to treat the constraints and obligations attached to resource rights as known and stable parameters, for the purpose of designing and implementing the optimal combination of investment and operational strategies from the standpoint of his business objectives.

temporarily. It is important to encourage the formation of markets for such rights and to foster the most numerous and diverse corps of participants. Speculators and brokers are often essential contributors to the flexibility and liquidity of markets. Their presence in a market is, moreover, a powerful deterrent to its manipulation or monopolization.

The Functions of Secondary Markets

Finally, the most effective institution for assuring effective competition and conveying accurate and timely information to resource owners, investors, and managers is a secondary market. The prices at which assets are sold in secondary transactions accurately reflect their current market value, without regard to the manner or prices at which they were initially distributed. Such a market — "white," "black," or "grey" — is an inevitable consequence of allocating the rights to a scarce resource at a price that is less than fair market value (and perhaps zero) on the basis of seniority or some other index of merit or need.

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In some jurisdictions, contracts for sale of timber from public lands attempt to maximize the value of successful bids subject to preservation of certain hard-to-value aesthetic and recreational values, by offering operators long-term contracts and wide discretion over harvesting schedules and techniques, and other variables that affect costs or expected revenues, subject to constraints like the following:

> No cutting of trees, disturbance of soils, or placement of wood or other wastes shall take place within 200 meters of a public road or trail, lake, or stream identified as capable of supporting anadromous fish, as shown on the current land-status maps of the State Division of Natural Resources. No logging or support activities may be undertaken during elk or deer-hunting season, on any weekend (between 6 p.m. Friday and 9 p.m. Sunday) from Memorial Day to Labor day inclusive, or between 6 p.m. on the day before any legal holiday and 9 p.m. on that holiday.

Preferential distribution schemes inevitably leave some goods in the possession of parties who put a lower value on them than do other parties whom the initial allocation left without. The greater the disequilibrium in values that results from the original allocation, the greater are the gains that resale transactions offer to both classes. *Secondary transactions therefore have no losers*; whatever the political rationale that may have justified allocating assets to some applicants at prices below market value, the secondary market offers them an opportunity to resell those rights at a profit.

Resales are thus the means by which an original recipient realizes the windfall he got when he received the asset at a price below its value. Those who were not beneficiaries of the initial distribution — despite a willingness to, but at the market price — gain by finally having the opportunity to do so. The secondary market thus places the apparent losers in the direct distribution in exactly the same place they would have been if the first round had been structured without discrimination among prospective buyers, to discover and collect the price that cleared the market.[16]

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16 The insight that a secondary market is often the best cure for much of the allocative mischief that stems from an existing, non-optimal allocation of some good, has its root in a famous essay by R.M. Coase. He pointed out that a two-party pollution issue can be solved in such a way as to maximize the total gain captured by the two parties, through bargaining between them, and that this bargaining would tend to arrive at the same remedy if the polluter agreed to pay compensation to the victim, as if the victim agreed to "bribe" the polluter to desist (Coase 1960; "Coase Theorum Symposium" 1973–74).

This principle is illustrated by a situation in which an upstream party discharges wastes into a stream from which a downstream party draws its water supply. Bargaining would lead them to choose the same physical arrangement, regardless of whether the rules of the community granted the upstream party (or anyone else) an unrestricted right to dump wastes or affirmed a right for the downstream party (or anyone else) to draw unpolluted water from the river.

Markets for Emissions Rights and Credits

The institutions directed at environmental protection that most clearly reflect the insights of economists about the potential advantage of markets for third-phase resource rights over various types of command-and-control regulation are sets of arrangements regarding specified atmospheric pollutants administered by the U.S. Environmental Protection Agency (EPA) and the state of California. One class of arrangement, called *bubbles*, permits operators to pool emissions from existing sources in a single plant or in different plants, which permits the pooled facilities to achieve a given total reduction by the lowest-cost set of modifications. By implication and intent, such cost savings also allow achievement of a greater volume of reductions than if they were mandated on a uniform point-by-point basis or by requiring installation of specified hardware at each point.

Offsets permit emissions rights for a new plant to be purchased with credits earned by a greater reduction of emis-

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16 - cont'd.

In the first case, the downstream party chooses between investing in purification facilities at intake or paying the upstream party to treat its waste. In the second case, the upstream party chooses between investing in a waste-treatment plant or paying the downstream party to treat its intake water. The lowest bribe by which the victim could obtain a clean water supply would be equal to the lowest penalty he could pay that would compensate his victim for the cost imposed on him; both are equal to the cost of the cheaper of the two remedies. Note that if law or custom did not specifically prohibit the polluting act or establish a right of access to clean water, the victim would have to pay for the remedy.

More importantly, regardless of how the rights and obligations were distributed, if there were no "market" in which the parties could weigh the benefits and costs of their respective options, the party to which law or necessity assigned responsibility would lose the ability to choose the cheaper remedy, but would be limited to that measure which could be implemented in his own jurisdiction.

sions at some other plant. Thus, the owner of a facility in which emissions can be reduced at relatively low cost is encouraged to sell credits for such reductions to the owner of a facility at which achievement of mandated reductions is more costly or unattainable.

Netting is the pooling of emissions from existing sources within a single plan, and *banking* allows a firm that earns credits for reducing effluents to hold them, rather than using them in another plant now, or selling them, in order to have the right to generate effluents at a new facility.

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Coase's seminal insight was not the special one-on-one example but rather that the ability of citizens to buy, sell, or exchange rights and obligations regarding resource rights or environmental conditions will enhance the values of those rights, or lead to an improvement in those conditions, to the advantage of everyone. This will be the case no matter whether these rights and obligations are specified in terms of a right to pollute, a right to be free of pollution, or an obligation not to pollute. And no matter how unfairly or arbitrarily those rights may originally be distributed, the ability to buy, sell, and exchange them will lead to a more satisfactory distribution, and a lower-cost resolution, than would be the case if no "market" existed for such rights or obligations. The more numerous the participants in the market, the more diverse the assets held by them, their technical options, and the wants they are trying to satisfy, the greater the likely benefits are likely to be, both to individual participants and to all participants as a group.

"Limited-entry" fishing rights in Alaska and other jurisdictions were originally distributed on the basis of seniority in the industry and measures of the applicant's economic dependence on fishing — criteria that were correlated with fishing skill, as reflected in the catch size and net income earned. Because there is a secondary market, however, permits have tended to gravitate over time to the most skillful and profitable fishermen, as the market establishes a price that exceeds the present value of the least skillful fisherman's expected future incomes, but lower than that of the most skillful. This price is, therefore, one at which a sale would make them both richer.

Winning applicants who are awarded oil and gas leases for a nominal fee are almost never capable of drilling for oil or have any intention of doing so. These lotteries thus make no sense, either from the standpoint or raising revenue or, at first impression, as a way to encourage energy production on the public lands. What motivates people to file applications in these lotteries is actually the hope of winning drilling rights that might be resold to that real oil company that was...

Excellent expositions exist regarding the mechanics of the various programs, their degree of acceptance, their relative effectiveness and prospects, and thus it is not necessary to repeat or paraphrase them (see, for example, Hahn 1989).

Performance of Existing Markets

Each of the elements of the EPA and California programs has been used in a few instances, but with one exception — lead emissions — the trading of emissions credits can not be regarded as a successful demonstration of the incentive approach to pollution control. Despite the prominence of emissions trading in President Bush's package of environmental policy proposals, EPA's rules in their present form have added little credibility or political appeal to tradable pollution credits as the principal framework for controlling air pollution, much less for making it the centerpiece for other environmental efforts, including water-quality or solid-waste management.

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...willing to pay the highest price. The use of a lottery to allocate these rights thus allows lottery winners to claim revenues that presumably would have gone to the government if it had auctioned the leases, but it is unlikely that it keeps much prospective acreage out of the hands of those exploration companies that regard them as most promising.

Existence of a market for emission rights would give polluters as a group an incentive to focus their efforts on the lowest-cost strategy for each pollutant. The flexibility to target the lowest-cost opportunities in a technically diverse population of plants allows each period's reductions to be achieved at far lower cost than by the application of "standards" (reductions to be achieved by individual pollutant source, or mandated technology). Over time, minimizing the cost of each period's progress allows the achievement of a more rapid rate of reduction.

EPA's Biases

In my opinion, the limited participation of industry in these programs is a result of the timidity and suspicion with which EPA and state officials have approached them, and the resulting narrowness of scope permitted by the implementing regulations. Moreover, restrictions on scope are aggravated by the stifling controls imposed on the actual use or trading of credits. The most definitive evidence that the EPA's top officials have been unsympathetic to the program's central concept is the agency's insistence, reiterated under three administrators, that emissions credits are not a constitutionally protected property right.[17]

The details of the regulations that implement this program are evidence of a similar bias among the mid-level staff whose specific duty is to administer it. The paramount concern that infuses the regulations appears to be an obsession that someone might really profit from trading credits (as opposed to reducing the cost of meeting prescribed standards). The regulations certainly do not indicate a belief that quantum improvements in air quality might be induced if the agency encourages entrepreneurs to contemplate really big profit opportunities from reducing harmful emissions expressly for sale, wherever and however an opportunity arises.

The only policy under which such markets are likely to yield big gains in air quality is one that hugely widens the scope of each market and the number and diversity of participants,

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17 How negotiable is an asset — that is, how secure is its value — when the agency whose authority created it repeatedly shows a lack of sympathy with its central rationale, and when the agency asserts a legal position that implies that it may at any time amend, confiscate, or abolish the instrument, simply by promulgating a new rule?

and greatly accelerates the reduction of total emissions permitted for each pollutant.[18] Such a policy would accept the certainty that some parties will find ways of making money by arbitrage and other purely financial transactions, and ways in which this would enhance the value of technical innovations having no direct impact on air quality. By accepting that certainty, the policy would disregard it in the confidence that the environmental and economic benefits of the program would far overshadow the opportunities it created to profit from seemingly "parasitic" transactions.[19]

Reductions in permitted emissions volumes directly increase the market value of emissions credits or other transferable waste-disposal rights, and acceleration of mandated reductions will result in sustained increases in market values. Higher values imply greater rewards per unit of emissions avoided, increases in the number of parties that have no recourse except to purchase credits, and an increase in the

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18 In a 1989 appearance before the California Energy Commission, I offered a number of suggestions for enlarging the scope and diversity of markets for rights to discharge various pollutants. These included procedures by which motor vehicles and other emitters could be merged into markets that are now confined to large stationary sources, and proposed that private parties and government agencies (including a trust fund established as a recipient for revenues from a proposed schedule of emissions charges imposed on sources not included in any markert for emissions rights) have the right to buy emissions charges not to resell them, but to withdraw them permanently from use in order to reduce permitted effluent volumes (Tussing 1989).

19 On grounds that go beyond the scope of this paper, I believe that arbitrage, pure speculation, and other purely financial transactions are not generally parasitic on "useful" transactions involving "real" goods. I would argue, given a proper place and sufficient time, that they are not only useful but essential to the efficient functioning of markets; that they encourage desirable changes in market structure and practices, and indeed, that the aggregate earnings of practitioners of such trades, like the earnings in most callings, are in reasonable proportion to the aggregate value of their activity to society.

number of parties that are able to earn credits at a cost less than the market price.

Widening the number and diversity of parties made eligible to earn, sell, buy, or bank credits will, however, combine with the higher unit price and the increase in numbers of credits demanded and supplied, to expand greatly the numbers and diversity of individuals and firms, and the volume of investment engaged in research, development, and implementation or new pollution-control strategies.

The Opposition to Market-Based Strategies

The last point serves as an appropriate transition to the final topic: the entrenched aversion on the part of prominent opinionmakers, a major part of the environmentalist community, and, probably, a plurality of those in the United States and Canada who have ever been exposed to proposals for creating markets and using economic incentives as the centerpiece of a strategy for the environment. I believe that the public-opinion and political obstacles to proceeding in the direction considered here are usefully classified as ideological anti-capitalism, excessive subtlety, and the timidity of advocates.

Ideological Resistance

First, it should occasion no surprise that the use of markets to deal with pollution evokes widespread opposition on moral and ideological grounds. Many people in our society are principled opponents of capitalism. Their attitudes reflect Christian, Marxist, and other doctrines that treat profit seeking as

inherently immoral as a driving principle of social action even in first- and second-phase sectors. People who hold such convictions are predictably repelled by suggestions that the rule of greed be deliberately enlarged (by privatization, for example) to embrace "social" concerns thus far delegated to public and nonprofit institutions and thus far judged by "higher" standards than commercial morality.

Many other people, who do not identify themselves with socialism or any ideological camp, neither understand nor much care about capitalism, the need for markets, or how they work. They are not part of the business culture, and regard corporations, businessmen, and profit seekers generally as greedy, dishonest, and unconcerned with the welfare of common people. They tend to assume, without reflection, that pollution and environmental harms are caused by big business because pollution is profitable, and because corporations do not care who gets hurt in their drive for profit.

Excessive Complexity and Subtlety

A market-based strategy not only provokes outrage from principled anti-capitalists, but is directly contrary to attitudes about business held by a large part of the population in Canada and the United States. It is, moreover, so subtle and complicated that one Ph.D. economist frequently has difficulty explaining it to another, and occasionally fails in the effort. The existing support for market-based strategies depends largely on faith that economists who advocate it know what they are talking about, plus a presumption that many educated people have that markets are more efficient than governments. Few people who hold this assumption are capable of a coherent explanation why this is the case. It is, in any event, a fragile

belief, particularly among businessmen, who often abandon it whenever talk turns to government enterprises or programs that favor their particular sector. It is hard to believe that a concept that seems so inscrutably complex is capable of mobilizing an effective constituency.

The Timidity of Advocates

The crucial obstacle to public acceptance of a market-based strategy for the environment is one whose remedy is also the most powerful antidote to anti-capitalist resistance and to seemingly unfathomable subtlety. That obstacle is the timidity and modesty of its advocates, with respect to the scope of influence proposed for it, in the modest objectives and results sought, and the humility of the claims made about its potential. Claims about the merits of this approach mostly emphasize economic efficiency — a concern that inspires only economists, and whose political appeal is exactly zero.

Recognizing the Revolutionary Character of the Program

Advocates of market-based strategies need to recognize that they imply revolutionary changes in economic structure and behavior and equally revolutionary changes in the ways people think about pollution and the environment. The rationale on which the proposed strategy is based are revolutionary in the same sense as the ongoing upheavals in Eastern Europe. Indeed, there are important common elements that our revolution would share with those of Eastern Europe. Poland, Czechoslovakia, and Hungary, among others, have already

decided to reorganize their economies around the principles of liberal capitalism, and to do so almost overnight. The reorganization required for third-phase activities in North America is no less profound than the task that Eastern European countries have taken on with respect to their whole economies.

The timing of the revolution against communism is exceptionally favorable for advancing radical changes in North America, in response to unusual challenges. The principal thesis I offer in the balance of this paper is that the institutions responsible for the spectacular performance of liberal capitalism in first- and second-phase activities hold promise of even more dramatic progress in third-phase performance.

Conventional timetables for reaching "realistic" and "achievable" goals in dealing with control and management of harmful wastes are exceedingly pessimistic beside the acceleration of innovation that could be expected to be the joint effect of the push from accelerating the schedule of mandatory reductions, and the pull that the resulting high prices for waste-disposal rights. No current projection of either possible or optimal performance reflects the likely movement of ingenuity and enterprise and in the structure of incentives.

A Frontal Attack

A frontal attack on the third obstacle to acceptance thus involves proposing timetables for abatement of specific pollutants at perhaps twice the most optimistic rates proposed by "responsible" mainstream institutions. The timetable would likely be even more demanding than those proposed by advocates of zero- or sustainable-growth paradigms. It would assume, however, that rapid progress toward environmental

goals, mediated by markets, would not require or cause a retardation in the growth of income and product. The analysis supporting acceleration of mandated goals will focus on the interactions between this acceleration, its effect on market values of discharge rates, and the profound shifts they will cause in the allocation of resources.

The radical acceleration of timetables, and an extravagant set of claims about what capitalist enterprise can accomplish, spurred by necessity and goaded by profit opportunities, dictates a change in rhetoric that banishes complexity. The argument has three parts:

- Mankind is on the eve of disaster, absent a more powerful set of remedies than political leaders, businessmen, and scientists have dared to propose.
- Only the complex of institutions organized by markets and driven by the search for profits has the power to do what must be done. The whole world now recognizes that liberal capitalist institutions are the only effective way to organize an economy. These institutions are everywhere being adopted as quickly as the tyrants and foreign armies that imposed other systems can be tossed out.
- The growth in volumes of most wastes now disposed of in harmful ways can be halted within five years, and decisively reversed by the end of the century. Progress is possible at this rate precisely because the technology and management devoted to pollutants and wastes lags by decades the performance of the extractive, manufacturing and service industries, which are organized around markets. The incentives, institutions, and a huge technological inventory are, however, available for nearly instant adaptation to problems of waste disposal.

Laying to Rest Accusations that Market-Based Strategies Involve Selling Out to Big Business or Licenses to Pollute

Finally, the revolutionary demands and promises will lay to rest any notion that a market-based strategy constitutes a sellout to big business, or an immoral grant of legitimacy to harmful ideas. Business will bear most of the primary impact of stricter standards, and of the pace at which they tighten further. The notion that emissions permits constitute a "licence to pollute" — that is, that they are a moral sanction to continue socially harmful practices — is correct when the initial standards conveyed "grandfather" rights to historic pollution levels at existing plants. Indignation over such policies was not limited to environmental extremists, when the regulations required new plants to buy emissions rights from incumbents who were still left with permits distributed *gratis*, permitting discharges of pollutants several times greater in volume.

Rapid shrinkage in permitted emissions of the most troublesome residues will impinge most severely on the formerly grandfathered rights of older plants. They will have fewer credits to sell or they will be forced to buy emission credits, at substantially increased prices. There would remain very little about tradable credits to justify condemning them as "licenses to pollute." The time will then be right to invert the semantics. In a tightening market for such rights, the accurate way to characterize them will be as pollution penalties, because the parties that have least reduced their emissions will be required to reward those who have achieved the greatest reductions.[20]

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20 The approach proposed here is fully compatible with positions expressed by influential mainstream elements of the environmental movement. In California, for example, the Sierra Club and the Natural Resources Defense Council...

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...agree that market-based incentives are potentially superior to command-and-control regulation, but note with exasperation that state agencies, including the California Energy Commission (CEC), which have long expressed an official preference for market incentives, have done almost nothing to implement them, even for matters under their direct jurisdiction. On November 6, 1989, the two organizations submitted comments to the CEC regarding its draft annual fuels report, stating in part:

> One of the most important new issues raised in the fuels report for this year is the possibility of using market-based approaches to improving environmental quality and energy efficiency, rather than relying exclusively on regulations. These issues are discussed cogently. However, the form of discussion — without specific action plans for Commission decisions, legislation, or other activities — seems to us to doom the proposals to failure, or at least to inaction in the foreseeable future.

The statement then reviews a series of CEC hearings and positions regarding economic incentives, beginning in 1983, and repeated failures to act:

> The failure to make progress on market-based programs is one of the reasons why the overwhelming majority of the CEC's predicted energy savings in the Conservation Report section come from its standards programs. It is not a consequence of standards necessarily being more effective than incentives, but, rather, a function of the fact that standards have been implemented successfully in the past, and new standards are in the process of being developed by the Commission at the present time. Unfortunately the same cannot be said about market-based programs (National Resources Defense Council and the Sierra Club 1989, pp. 3–4).

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The Economic Approach to Environmental Issues

D.G. McFetridge

There is a tension between economists and environmentalists that ought not to exist. The message of both groups is essentially the same: there is no free lunch. The apparent inability of economists and environmentalists to work together is unfortunate in that it has almost certainly raised the cost of making environmental improvements and complicated the process of adjudicating environmental disputes.

Some of the tension between the two groups arises from inflated rhetoric and from a failure to define the terms being used. The purpose of this paper is to describe, from an economist's perspective, the economic approach to environmental issues.* It concludes, not surprisingly, that the failure of environmentalists to appreciate the merits of the economic approach has been counterproductive in that it has frustrated environmental management and quite likely slowed the process of environmental improvement.

While the environmental movement embraces a considerable range of opinions, it is generally characterized by a suspicion of market processes and market-style incentives. To

* I would like to extend my thanks to Professor Doug Smith for his advice and comments on an earlier draft of this paper.

environmentalists, markets are part of the problem rather than part of the solution. To economists, markets and market incentives, while far from perfect, are seldom the cause of environmental problems and can often be part of the solution.

Environmentalists argue that the market system is biased toward present consumption and, as a consequence, does not provide adequately for future generations. This argument is examined in the first section.

Environmentalists also argue that the market system is responsible for air and water pollution and for the extinction or threatened extinction of many species of flora and fauna. While it is not universal, there is a tendency in environmental circles to argue for technological and ethical solutions to these problems rather than for the harnessing of the demonstrated power of individual self-interest, as economists are inclined to advocate.

Specifically, environmentalists maintain that the overuse of common-pool resources such as the air, water, and some species of wild life should be dealt with by discouraging certain types of economic activity — namely, those based on "contrived wants" rather than "real needs" — and by requiring that any pollution resulting from the fulfillment of "real needs" be held to the technologically achievable minimum. They are uncomfortable, to say the least, with the economic view that the benefits derived from polluting activities should be compared with the damages resulting from pollution, and that it is not necessarily the case that technically feasible abatement is also economically worthwhile. These and related issues are addressed in the remainder of the paper.

Markets, Governments, and Future Generations

Environmentalists are of the opinion that the market system does a poor job of allocating natural resources over time. In their view, market decisions systematically overexploit these resources in the present and leave too little for the future. These decisions, they argue, must be corrected by public policy. For example, Paehlke (1989, p. 141) writes:

> We must discover ways to leave in place the real efficiencies of markets while inserting nonmarket values such as intergenerational equity and sustainability....Energy price increases, for example, should perhaps be imposed politically, along with increases for other key nonrenewable resources.

The implication is that market participants are less well informed regarding future scarcities or less willing, or less able, to respond to them than are government planners. There are two sorts of response to this type of argument. One is to compare the respective records of governments and markets in providing for the future. The other is to make a conceptual comparison of the means by which future generations can influence market and political decisions respectively.

There is certainly little in the record of Canadian, U.S., or European governments to indicate that they are especially adept at husbanding resources for the future. The Brundtland report (World Commission on Environment and Development 1987, p. 123) cites the environmental consequences of government subsidies to agriculture:

> The environmental consequences of a heavily subsidized production system are becoming evident within industrialized nations:
>
> - lower productivity as soil quality declines due to intensive soil cultivation and overuse of chemical fertilizers and pesticides;
> - the destruction of the countryside through the clearing of hedge rows, park belts and other protective cover and the levelling occupation and cultivation of marginal land and watershed protection areas; and
> - nitrate pollution of ground-water, aquifers due to the often subsidized overuse of nitrate fertilizers.

The Brundtland report (ibid., p. 195) reached similar conclusions regarding the effect of government policies on energy use:

> The high level of hidden subsidies for conventional fuels built into the legislative and energy programmes of most countries distorts choices against renewables in research and development, depletion allowances, tax write-offs, and direct support of consumer prices.

A number of scholars regard the management of government-owned forest lands as both economically and environmentally unsound:

> The case against current management practices [of public lands] is rather easy to make and generally not a point of contention among resource economists (Hanke 1985, p. 222).

Some scholars have found even those government departments mandated to deal with environmental problems fail to

take the long view. Barnett (1985), for example, finds that in its administration of the environmental superfund for toxic waste disposal, the U.S. Environmental Protection Agency (EPA) proved to be both "myopic and risk averse." Environmentalists frequently attribute these characteristics to market participants.

The waste of natural resources caused by government policy is not confined to western economies. It is also prevalent in the Soviet Union and other eastern European economies. A recent documentary shown on the CBC described the effect of the diversion of rivers formerly flowing into the Aral Sea in the Soviet Union. The area of this once-large body of water has been reduced by one-half, with disastrous consequences for the fishery, for wildlife, and for local climatic conditions. The diverted waters have been used for irrigating crops not suited to local soil and climatic conditions. The result has been soil degradation and pollution of runoff waters.

Market decisions can also be wasteful. But some of this is waste in hindsight. Given better information, different decisions might have been made. Of course, information is also costly and it is important to balance the gains from making a better informed decision against the costs of acquiring the requisite information. In other cases, resources may be exploited too quickly and too early because property rights are insecure or nontransferable. Faced with a choice of "using it or losing it," resource owners may engage in premature exploitation.

In yet other cases, there are problems of measurement and certification. For example, Hausman (1979) and others have found that low-income groups tend to discount the value of future electricity savings very heavily in their choice of air

conditioners. One reason for this is that if they live in rented accommodation, they may not pay directly for the electricity they use. A second reason is that those with low incomes may not understand or believe assertions regarding the relative energy efficiency of various air conditioners. A third possibility is that lower-income groups do not have the same ability to "borrow" against future energy savings as do higher-income groups.

It is important to understand that this is not so much a general market problem as it is a specific incentive problem resulting from the cost of direct measurement of electricity consumption by individual renters and by individual appliances over time. Given new measurement technologies, these problems may disappear.

There is evidence that when property rights are well-defined, secure and transferable resource owners take proper account of future demands. A good example is in the management of privately held timber tracts. Their owners do not lay waste to them at the first opportunity. Instead, they are exploited so as to provide a flow of income over time that maximizes their present (capitalized) value. Berck (1979) finds that the private owners of Douglas fir stands in the United States effectively discount the future at about 5 percent, a discount rate which is considerably below the 10 percent often employed as a social discount rate. Berck concludes that private entrepreneurs do not harvest their timber sooner than is optimal.

This discussion implies, in sum, that governments do not necessarily take the long view, making risky long-term investments on behalf of future generations, and that markets are not necessarily short-sighted. Moreover, some instances of

market short-sightedness can be attributed to government intervention to alter market outcomes or the threat thereof.

More fundamental is the question of whether the political system is necessarily better placed than the market to take the long view. The demands of future generations are reflected in market decisions by virtue of the capitalization of expected future profits and the transferability of the rights to capitalized profits in the form of either direct ownership of natural resources or ownership of shares in resource-owning corporations. Excessive exploitation in the present reduces the flow of future profits and, hence, the value of the resource. Owners have an incentive to maximize the capitalized value of the resource. This depends on having supply available to meet the demands of future generations.

In the political system, things are different. Future generations cannot vote. Future generations have a voice in the political process only to the extent that the current generation gains utility from having provided collectively for them. Of course, this collective altruism may simply reduce the private intergenerational transfers — that is, the financing of education and bequests — that would otherwise occur, leaving future generations no better off.

The implication is that governments historically have shown no special concern for future generations nor are they necessarily structured to do so. The argument that substituting political for market decisionmaking necessarily improves the lot of future generations is simply incorrect.

But this conclusion is only the starting point for thoughtful analysis. Governments do intervene. The important question is how to structure the political process so that this intervention is less wasteful than it has been in the past. While there

may be merit in preaching against government subsidies to agricultural production or energy megaprojects, it is perhaps more useful to make the political process less vulnerable to interest groups seeking subsidization.

The process by which well-organized interest groups use the political process to extract wealth from taxpayers at large and in so doing waste resources is what economists call "rent-seeking." Economists argue that one way of reducing the incidence of rent-seeking is to make the budgetary and regulatory processes more systematic, open, and transparent. Among the means of doing this is to make greater use of formal benefit-cost analysis. In the present context, this would imply, first, that proposed environmental regulations be subject to benefit-cost analysis. Second, public-sector investments would receive similar scrutiny, with environmental costs factored in. Adherence to the canons of benefit-cost could, in principle, filter out all wasteful wealth transfers and, beyond this, could emphasize that it is the full cost, including damages imposed on others, which is relevant for project evaluation.

The Economic Approach to Common-Pool Resources

The problem of common-pool resources is that if access is not restricted or rationed in some fashion, they will be overused. Overuse means simply that the benefits derived by the marginal user are less than the reduction in benefits suffered by — or damages imposed on — competing users.

Economists assume that common-pool resources exist for human use and that our goal — indeed, our duty — is to maximize their present value. Maximizing present value means

maximizing the discounted flow of benefits (rents) that they yield over time.

Maximization of the value of common-pool resources can be achieved by either of two broad sets of institutions:

- decentralized or market enforcement of property rights; or
- centralized or administrative enforcement of property rights.

Under decentralized enforcement, the role of government is limited to defining the property right. Rights may also be both defined and distributed by the courts. The process of allocating common-pool resources to the highest-valued users then occurs under the guidance of tort or contract law.

Decentralized enforcement has worked well in cases involving readily identifiable sources of noise or noxious emissions. It has also been effective in the management of water quality, some species of wildlife, and scenic areas. The greater use of property rights in the preservation of such species as the African elephant and the rhinoceros has also been suggested (Block, 1989, pp. 311–318).

Centralized enforcement is more effective when a common-pool resource has a large number of users and the precise source and nature of the damage suffered by any one user or group of users is costly to establish and to redress. This is true of pollution of large bodies of water, certain forms of air pollution, the ozone layer, and global climatic conditions. Under centralized enforcement, common-pool resources are allocated administratively. Much potential remains, however, for the use of market tests and market-style incentives.

Centralized enforcement has two components. The first is the determination of the volume of use that maximizes the net

present value of the resource. This is generally approached incrementally by calculating the net benefit resulting from a hypothetical change in the current pattern of use. For example, the cost of a proposed reduction in sulphur dioxide emissions could be compared with the reduction in damage to human health, lakes, forests, and structures that it would bring about. Emission reductions should be pushed to the point at which the cost of further reductions is at least as great as the resulting reduction in damages.

Once the desired reduction in emissions or, more generally, in the level of use of a common-pool resource has been determined, the second component of the process begins. This involves the determination of which emissions or, more generally, which users are cut back and by how much. One possibility is to require a *pro rata* reduction in all emissions. Another possibility is to reduce emissions first where it is least costly and proceed through the more costly cases until the target level of emissions is reached. A feature of this second approach is that emissions are reduced most where it is least costly to do so. As a result, the cost of reaching the target level of emissions is lower (unless abatement costs are the same for all sources of emissions) than with an across-the-board reduction.

Notice that if emissions are reduced in the least-cost manner, the total reduction in emissions that can be justified in benefit-cost terms is also greater. Thus, an insistence that all sources of pollution be cut back in the same proportion, while understandable, is counterproductive. It reduces the total amount of abatement that is economic and, in a political context, reduces the total abatement to which the parties involved are likely to agree.

A cost-minimizing pattern of abatement can be induced by a number of mechanisms. One alternative of long-standing

interest to economists is an emissions *charge or tax*. If the charge were set equal to the damage imposed by a "unit" of emissions on others, it would have the effect of reducing emissions to the point that the cost of additional abatement is just equal to the damages imposed on others — that is, to the efficient level. It would also result in the equalization of marginal abatement costs among sources of pollution — that is, in the minimization of total abatement costs.

The same result can be achieved in principle by an abatement *subsidy*. In this case, polluters receive a subsidy for reducing emissions. Ideally, the subsidy is equal to the resulting reduction in damages.

The emissions charge and abatement subsidy can be allocatively equivalent — that is, they can result in the same level and pattern of abatement. They have different consequences, however, for the distribution of income or wealth. In the simplest terms, the emissions charge is a fee paid *by* the polluter, while the abatement subsidy is paid *to* the polluter. The choice between the two is equivalent to deciding who owns the common-pool resource. Do polluters have a right to discharge waste into the water or the air (abatement subsidy) or do other users have the right to be free of pollution (emissions charge or tax)? There are a number of economic, legal, political, and ethical factors that must be considered when answering this question. Some of these are examined later in this paper.

The emissions charge and the abatement subsidy have some common features to which environmentalists often object. Unlike the strict regulatory approach, they do not require all (or perhaps any) polluters to undertake the maximum abatement that is technically possible.

Some polluters may choose to pay the charge or forego the subsidy rather than to engage in abatement. This is acceptable

to economists as long as the fee paid or the subsidy foregone is sufficient to cover the damages imposed on others. What bothers environmentalists is that emissions are not fully eliminated even when it is technically possible to do so. The fact that some polluters appear to the public to have "escaped" equal environmental scrutiny also poses political problems.

Another means by which the cost-minimizing pattern of abatement can be induced is through a system of emissions permits. In this case, the total allowable level of emissions is set in a benefit-cost context. In one variant of this approach, emissions permits are distributed among existing sources of emissions in proportion to their historic share of output (if they are in the same industry) or emissions. Given that allowable emissions are less than historic emissions, polluters must either undertake abatement or acquire more permits. If the permits are transferable, the polluters with higher abatement costs will purchase permits from those with lower abatement costs. If large numbers of permit holders are involved, the price of an emissions permit should tend to the marginal cost of abatement. As a consequence, the marginal abatement cost of all polluters is the same and the total cost of abatement is minimized.

Emissions permits need not be given to existing sources of pollution. In short, these could be "grandfathered." The permits could also be auctioned off by government. In either case, the polluters bear the cost of abatement. The difference is that grandfathering leaves the savings from efficient abatement in the hands of the polluters, while with an auction these savings accrue to government.

Both emissions charges and permits have been employed in a number of jurisdictions. For various reasons, they have

not often been employed in the textbook fashion described above. The causes and implications of this are examined in the next section.

Experience with Emissions Charges and Permits

Marketable Permits

Definition

Under a marketable-permit scheme, the appropriate level of environmental quality is defined in terms of allowable emissions. Permits are allocated to firms, generally on the basis of historic emissions or output. These permits enable the owner to emit a specified amount of pollution. Permits can be traded and sometimes banked. As a result, abatement is undertaken by the firms with the lowest abatement costs. Firms with higher costs buy the permits. This system minimizes the cost of achieving the desired level of abatement, provided that the market is competitive.

Examples*

Marketable Effluent Permits: A system of marketable effluent permits was introduced in 1981 at Fox River, Wisconsin. The permits last for five years and allow the holder to discharge effluent with a specified biological oxygen demand (BOD).

* Examples are taken from Hahn (1989).

Permits were granted to two types of users: pulp and paper mills and municipal waste treatment plants. With only one trade in six years, however, the system has not been effective, for several reasons:

- trading is allowed only for those with a demonstrated inability to introduce abatement technology or for new entrants who in any case must install state-of-the-art abatement;
- the value of permits is uncertain since the acquiring party does not necessarily get the permit after it is reissued; and
- permits are a very small part of the regulatory structure.

Emissions Trading: The EPA allows limited trading in the right to emit carbon monoxide, sulphur dioxide, and nitrous oxides. Trading may take any of four forms: netting, offsets, bubbles, and banking.

- *Netting* allows new emissions from a plant provided they are offset by emission reductions elsewhere in the same plant. This is also called "internal trading."
- *Offsets* is the practice of allowing new emissions in areas in which air-quality standards have not been met provided they are offset by greater reductions in the same plant or other plants in the same area. Offsets can thus be obtained either by "internal or external trading."
- *Bubbles* are an aggregation of all sources of a given pollutant in a particular plant. Required emissions reductions can take place where it is least costly.
- *Banking* is the process by which emissions below a required level can be "saved" and used or sold in the future.

The cost savings from netting and bubbles, both of which involve only internal trading, are thought to be very large but are also uncertain. Most offset and banking trades have also been internal. These measures have also resulted in considerable cost savings (Hahn 1989, pp. 100–101).

External trading has been minimal and its cost-saving potential remains unrealized, for two apparent reasons. First, the program is an adjunct to an extensive system of environmental regulations that require, among other things, state-of-the-art abatement in all new plants. Second, the EPA has left the rights inherent in a permit deliberately ambiguous precisely to discourage external trading. The reason for this is, in turn, that external trading is visible, and it antagonizes environmentalists who (correctly) see grandfathered emissions permits as a right to pollute (at some level).

Lead Trading: During the 1982–87 period, the United States reduced the lead content of motor gasoline. Each refinery received lead rights equal to its current production times the current lead-content standard. If the lead content of a refiner's gasoline production was below the total allowed amount, remaining lead rights could be sold or banked.

This program is regarded as having been effective, since a considerable amount of trading in lead rights did occur and there was a significant refiner cost saving as a consequence. The program's success apparently was due to well-defined lead rights, in the sense that the lead content of gasoline could readily be monitored and because the lead content reduction goal was widely agreed upon and understood — that is, environmentalists accepted a limited "right to pollute" in this case). Moreover, lead rights were readily tradable.

Emissions Charges

Definition

In principle, an emissions charge is levied on a per-unit-of-pollutant basis. The unit charge can vary with the nature of the pollutant and with the concentration and time period of emission. Again, in principle, the fee should be equal to the damages imposed on competing users. In other words, the fees should be equal at the margin to the decline in the value of the resource to other users.

If emissions charges are set in this fashion, several results follow:

- the value derived from emissions must be at least as great as the sum of the costs imposed on competing users;
- emissions abatement will be introduced to the point at which the cost of abatement equals the emissions fee; and
- investments in abatement will be distributed efficiently among polluters.

Examples

Emissions or effluent charges tend to differ significantly from the ideal. They are often not related directly to emissions and, as far as can be discerned, are not based on the damages inflicted on competing users. In France, for example, effluent charges do not vary with the volume or content of effluent, although the sewage tax is volume-related and discharge permits are priced according to discharge content. In West

Germany, effluent charges cover a wide range of pollutants and are related to volume and concentration.

The Netherlands has the highest effluent charges of any industrial country. These are set on the basis of volume, concentration, and the nature of the discharge, with the actual emissions of large users being monitored. These charges are said to have been very effective in reducing water pollution.

User charges levied by waste-water processing utilities in the United States are based on volume and concentration. Hahn (1989) concludes that these charges are not enough to cover the cost of these facilities or to affect the behavior of polluters. In their earlier study, Baumol and Oates (1979) cite evidence that conflicts with Hahn's conclusion on responsiveness. They find U.S. studies that show elasticity of BOD discharge with respect to effluent fees of between 0.5 and 0.8.

A number of Canadian cities levy effluent charges based on BOD, suspended solids, and grease. Some have found their system of charges to be effective and easy to administer (Chant, McFetridge and Smith 1990). Response elasticities of BOD and suspended solids discharge to changes in effluent fees on the order of 0.5 have also been found in Canada.

Ways to Reduce Emissions of Chlorofluorocarbons and Halons

The agreement to reduce the production of ozone-depleting chlorofluorocarbons (CFCs) and halons illustrates some aspects of the economic approach in operation. The analysis leading to the signing of the Montreal Protocol has been described by Smith and Vodden (1989). Their discussion emphasizes two issues. The first is the benefit-cost analysis of

various hypothetical reductions in production of CFCs and halons. The second is the means by which the agreed-on reduction is to be implemented.

The benefit-cost analysis compares the value derived from the reduced incidence of skin cancer and cataracts with the increase in costs resulting from the use of substitutes for CFCs and halons in manufacturing or from the use of substitutes for products containing CFCs and halons. The analysis shows that:

- large net benefits can be derived from the reduction of CFCs and halons provided this action is undertaken by all the major using countries; and
- the restriction of the output of products containing CFCs or halons also increases profits of the respective producers of these products.

The implementation of the agreed-on reduction in CFC production is to be achieved by granting existing producers of CFCs production rights in accordance with historic market shares. The amount of production allowed under these rights is to decline over time. As a result, the prices of CFCs and halons will increase and the industrial users with the most elastic demands — that is, those who can substitute for CFCs and halons most readily — will be rationed out first.

The right to produce CFCs is defined in terms of ozone-depleting potential (ODP). Since fluorocarbons differ in their ODP, producers are free to alter the mix of CFCs they produce as long as their ODP total remains within their allotment. This is similar to the "bubble" concept described above. It leaves producers free to reduce the production of some CFCs by a greater percentage than others. Again, this allows for a greater

reduction in production and use of the CFCs that are the least essential.

The ODP right itself is not tradable or bankable, thus ruling out forms of adjustment involving a greater-than-proportionate ODP reduction by some producers of CFCs. An example of this form of adjustment would be the elimination of all production of CFCs by one producer, who would then allocate his right to other producers who would supply his customers. Whether the efficiency sacrifice resulting from the nontradability of ODP rights is large is unclear.

The experience with emissions charges and tradable management systems suggests three summary conclusions. First, they have had a limited role in environmental management systems. The emphasis has instead been on emissions controls and standards. Some say that this is because charges and permits are impractical. A more persuasive explanation is that — with a few exceptions, such as lead permits — charges and permits have been politically unacceptable. In part, this is a consequence of opposition from environmentalists, who object both to the right to pollute to a prescribed level and to the right to "pay and pollute" beyond this level that charges and permits imply.

A second conclusion is that emissions permits have been used principally in the United States. While they have reduced the cost of achieving emissions standards, most of the cost saving has resulted from internal (within plant) trading. External trading has been limited both by the simultaneous imposition of abatement requirements and by the vague nature of the rights inherent in a permit. External lead trading occurred on a considerable scale because gasoline lead content had been measured and reported for years and because lead content was

scheduled to go virtually to zero. The lesson seems to be that environmentalists do not necessarily oppose flexibility in eliminating emissions. Rather, they appear to oppose flexibility when it leaves overall emissions above the technically achievable level and when it leaves some polluters above the "average" on a long-term basis.

Third, emissions or effluent charges have been employed extensively in Europe and North America. They are generally not intended to cover either the damages resulting from emissions or the cost of abatement — that is, waste treatment. Indeed, in some cases they are not related to the volume and nature of emissions involved. The reason may be that measurement costs are too high. It may also be political in that segments of the environmental community find unacceptable the concept that pollution is allowable if the polluter can compensate others for any damages suffered.

There may well be significant operational barriers to the implementation of permit or charge schemes in some cases. It may also be, as some have argued, that permit schemes are simpler to design and operate than charge schemes. This remains to be demonstrated.

Unfortunately, the use of permits and charges may also have been inhibited by misinformed opposition from the environmental movement. While permits and charges do allow some firms to pollute more than others, they can reduce the overall level of emissions to the point where the cost of further abatement exceeds the damages avoided.

Opposition to permits or charges is also unfortunate in that these schemes can be effective in reducing the cost of adjusting to stricter emission standards. The lower the cost of adjustment the greater is the reduction in emissions that is both economic and politically negotiable.

Who Pays?

The notion that "the polluter must pay" has widespread adherence. This proposition is, in fact, quite vacuous. Moreover, it is neither efficient nor likely to be realized consistently in a democracy. There are several reasons for this assertion.

The control of pollution is first and foremost a problem in resource allocation. A common-pool resource such as the air or a body of water must be rationed to prevent overuse, which occurs when the benefits derived by any one user are coming at the expense of other users.

A number of rationing systems can, in principle, yield the same outcome. Each has different implications for income distribution. In the simplest terms, users who are rationed out lose surplus while the remaining users experience a gain. Under some schemes, those rationed out are effectively compensated; under others, they are not. The question arises as to which approach should be chosen and, given the workings of a democratic government, which approach is likely to be chosen.

The incidence of the cost of emissions reductions is likely to be widespread. The cost of goods or services produced with polluting processes will rise regardless of the means by which emissions are reduced. As a consequence, consumption of these goods and services declines and remaining consumers suffer a loss in surplus. Factors specialized to the production of polluting products also suffer a loss in surplus as the demand for their services declines.

Factors can be specialized by location or by function. Workers in remote pulp and paper mills are specialized in the sense that alternative employment may be hundreds of miles

away. A reduction in the demand for their services may result in a loss of wages and property values, and may require that relocation costs be incurred. Local businesses formerly catering to these workers also suffer a loss in value.

To the extent that the firms involved have made investments in specialized facilities making use of polluting processes, their shareholders will also suffer losses. The important point is that the public discussion seems to assume that the burden of abatement falls only on the shareholders (capitalists) when, in fact, it is much more widely spread. Unless this is understood, it will be hard for abatement proposals to win political acceptance.

It should further be emphasized that the redistributive effects of rationing common-pool resources go well beyond the users involved. Redistribution can occur within industries between large and small firms or between incumbents and potential entrants. Redistribution can also occur between industries. The Ontario government's preference for steel rather than aluminum beer cans had as much to do with the respective locations of large steel producers (Ontario) and aluminum producers (Quebec) as it did with the environment.

Thus, the question of who pays or, more appropriately, who gains and who loses from reductions in emissions or other environmental measures is not as simple as it has been painted. The question of who *should* pay has a simpler answer, but again, it is likely to meet with considerable resistance from environmentalists.

Economists argue that when there are competing uses of a common-pool resource, the highest-value use should prevail. It is important to understand that competing uses are just that. Discharging effluent into a river may rule out fishing and

swimming, but these recreations may also rule out the production of the waste-producing good or service in that location.

It is often costly for a higher-valued user to buy out a lower-valued user. These costs can be saved if the higher-valued user is given the right to use the resource at the outset. To return to the analogy used above, if the river is more valuable in providing recreation than waste disposal, then recreational users should have the initial right to use it. A potential pulp mill would not be able to compensate recreational users and would not locate there. If, however, the mill were the higher-valued user, the allocation of rights should be reversed.

Allocation rules must also take account of history. A polluter may have begun operation when there were no alternative uses for a common-pool resource — for example, a pulp mill in an area that later became popular for recreation, or an airport that has become surrounded by residential neighborhoods. As alternative users emerge and abatement becomes desirable, the question again arises as to who should pay for it. There is a good case to be made for granting prior users an "environmental easement," which would imply that the newcomers — who have, in a sense, invited the damages they are suffering — should pay for abatement, otherwise they have no incentive to act in a manner that minimizes the damages they suffer.

In summary, economic efficiency considerations imply that, in some cases, there will be a right to pollute, and in others, a right to be free of pollution. In some cases, the polluter should pay for abatement (bearing in mind the discussion above regarding the incidence of abatement costs); in others, competing users should pay.

The determination of who actually does pay for abatement will frequently be made by the political system. Political decisions are, in turn, the result of the interplay of contending, rent-seeking interest groups. The rationing of access to common-pool resources is virtually certain to have significant redistributive effects in many instances. Interest-group politics then may influence, to a considerable degree, the decision regarding who pays for abatement.

The theory of interest-group politics predicts that when interest groups confront one another, concentrated groups with a large amount of wealth per member at stake will prevail over more dispersed groups with a larger total amount but a smaller amount at stake per member. The implication is that specialized users of common-pool resources may successfully resist political action to ration their access if they are concentrated and if competing users of the resource are widely dispersed and suffer relatively small per capita damages. Thus, a concentrated group with large per capita rents at stake may require the right to pollute politically. Abatement would then have to be subsidized. Of course, the right to be free of pollution could also be acquired politically. In this case, a polluter would have to pay for abatement or pay compensation or both.

Economic theories of public decisionmaking predict that the right to use a common-pool resource may go to the most politically effective users rather than to the highest-valued users. If compensation — that is, the transfer of the right — is costly to arrange, both privately and collectively, then a common-pool resource may remain "in the wrong hands" for a considerable period of time. As a practical matter, this could mean either too little or too much industrial development.

Of course, the economic waste associated with interest-group politics is not confined to natural resources and envi-

ronmental amenities. There is a general interest in altering the policymaking process to reduce the extent to which special interests can prevail over the general interest. A more open, systematic, and transparent policymaking and adjudication process could reduce the power of special-interest lobbies.

One way of making the adjudication process more systematic is to apply the principles of economics — specifically, comparing, in a consistent fashion, the net economic benefits of alternative courses of action. Environmentalists have opposed benefit-cost comparisons on the grounds that some costs are difficult to measure and some benefits are based on what they regard as unnecessary consumption. The point is that any decision regarding the use of common-pool resources has implicit in it a benefit-cost calculation. The economic approach merely makes this explicit, thereby helping to discipline the policymaking and adjudication processes.

In summary, although the phrase "let the polluter pay" has a nice ring to it, it is vacuous. The incidence of the cost of abatement is likely to be widespread. Consumers, workers, suppliers, and shareholders may all bear part of the burden. Second, economic efficiency (broadly defined) is served by awarding a right to pollute in some instances and a right to be free of pollution in others. This implies that emissions charges may be appropriate in some instances and abatement subsidies in others. Third, the political system is likely to award rights to pollute or to be free of pollution to the interest group that can lobby most effectively for it. Finally, while the question of who pays is likely to occupy a disproportionate share of the public debate on environmental measures, the more important issues are the determination of the amount of abatement and the cost of minimizing distribution of abatement efforts.

Conclusions

Environmentalists could further their cause by accepting the principle that natural resources exist for human benefit, and by recognizing that the waste from resource use can be avoided by submitting to the discipline of market processes and by applying some basic principles of economics to public environmental management.

This implies, first, a recognition of the role that secure, transferable property rights can play both in the allocation of resources over time and in the management of resources that have hitherto been treated as common property.

Second, in the cases in which it is more efficient to manage common-pool resources collectively, management should compare the respective benefits of competing users. Where a reduction in use is required, the cost of effecting this reduction should be minimized. In practical terms, this implies that required abatement of emissions need not approach that which is technically possible. It also implies that efficient abatement generally requires that some sources of pollution be reduced proportionately more than others.

These principles also apply internationally. There may be merit in Canada's "raising the consciousness" of other countries by being "out in front" on global environmental issues. It may also be the case, however, that in some instances abatement may be more costly in Canada than in other countries. Thus, maintaining a "green" image may not always be advantageous from either a Canadian or a global efficiency point of view.

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Greening by Market or by Command?: Rapporteur's Report and Comments

Richard G. Lipsey

In this chapter, I report on what seemed to me to be some of the more interesting of the themes that were developed during the conference. I then go on to play some of my own variations on those of the themes that seemed complex enough to call for further elaboration.

Global Warming: An Illustration

Bruce Doern reflects the views of many of the participants in this conference when he tells us that the public is well ahead of the politicians in perceiving the many real environmental problems that this country and the world currently face. Others have told us that the politicians may now be catching up with public opinion — that politics, as well as public opinion, is in for a "greening." Kenneth Hare warns us, however, that global warming may not be one of the real problems that should be concerning everyone.

Hare's analysis was strongly questioned from the floor. In particular, his assumption that global mean temperature would be unchanged in the absence of a warming effect was asserted to be unrealistic in the light of the many known forces

causing mean temperature to change in the long term. Hare's answer, which seems satisfactory to me, is that these long-term forces operate to change mean temperature over periods of many centuries or, more usually, many millennia. In the global warming controversy, however, we are interested in mean temperature changes over decades. For these short-term purposes, making the *ceteris paribus* assumption implied by attributing all changes in mean temperature to global warming is a reasonable procedure.

Diagnoses under Uncertainty

We must take care in how we interpret Hare's cautious analysis of the warming issue. A superficial reading might take him to be saying that scientists really cannot deal with such a complicated problem because they can never establish sufficiently secure knowledge about it. This, however, is not his message as I read it. Instead, the message seems to me to be that global warming, if it exists at all, is taking place over a period that is long in relation to the period over which we have reliable observations. Results are, therefore, not yet conclusive. That there has been some warming is clear. That this warming is a random fluctuation, rather than the manifestation of an underlying trend, is an hypothesis that existing evidence cannot reject at any of the conventional levels of confidence. Nonetheless, as I read the data that Hare reports on, if you had to make a single accept/reject decision on the null hypothesis that global warming does *not* exist,[1] the best decision, based on the

1 When testing for the existence of anything, from global warming to defective light bulbs, statisticians set up a null hypothesis that the alleged thing does *not* exist. Rejection of the null hypothesis on the basis of evidence means that...

available data, would be "reject the null hypothesis and assume that global warming does exist."[2]

Decisions under Uncertainty

In the light of these results, Arlon Tussing states that it is too early to base policy on the assumption that a trend toward global warming has now been established. Two comments on Tussing's statement are required.

First, in an uncertain world, the decision to reject the null hypothesis that a particular cause of environmental degradation is not present will depend on the cost of making what statisticians call "type 1" and "type 2" errors. We need to ask: What will be the cost of making the error of rejecting the null hypothesis when it is correct? The answer usually is that the cost is some wasted expenditure on unnecessary remedies. We also need to ask: What will be the cost of making the error of accepting the null hypothesis when it is wrong? Here the answer will depend partly on the lag between deciding to take remedial action and that action's beginning to reduce the environmental degradation. If, for example, there is a ten-year lag between these two steps, the cost of postponing action may be high; if we wait to institute remedial action until the

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...the evidence is taken to support the existence of the thing in question. This is a simple enough procedure, but the meaning of the double negative — *rejecting* a null hypothesis that the thing *does not exist* — as accepting that the thing does exist, can easily be misunderstood.

2 This "yes-no" choice is made by rejecting the null hypothesis of *no global warming* when the odds on it being correct are anything less than 1 in 2; the normal, cautious approach calls for rejecting the null hypothesis of *no global warming* only when the odds on it being correct are less than either 5 or 1 in a hundred.

degradation is *currently* perceived to be serious, the degradation may have become disastrous by the time the remedy begins to take effect. Each case must be judged on its own empirical merits. It is important to understand, however, that choices are always made under uncertainty and, in each decision period, the cost of wrongly accepting, and wrongly rejecting, the hypothesis must be assessed and appropriately weighted by the probability either that the null hypothesis is right or that it is wrong.[3]

Second, whatever caution people such as Hare and Tussing suggest, the world is unlikely to wait for better proof. Global warming has caught the public's imagination. Analyses such as Hare's can only be used to urge a note of caution: Do not commit too many resources unless, and until, the evidence becomes somewhat stronger than it now is.

Appropriate Jurisdictions for Decisions

Global warming, if it is a problem, requires global solutions. Not all phenomena have so general an impact, and it is important to establish the appropriate level of jurisdiction before tackling any particular problem. The appropriate level

3 To illustrate, assume that the cost of incorrectly rejecting the null hypothesis is an expenditure of $2 billion worth of unnecessary remedial action, while the cost of incorrectly accepting the null hypothesis is $50 billion worth of preventable environmental degradation. Now suppose that the probability is 0.1 that the null hypothesis is wrong and 0.9 that it is correct. This makes the expected value of rejecting the hypothesis ($2 billion) (0.9) = $1.8 billion, and the expected cost of accepting it ($50 billion) (0.1) = $5 billion. Clearly, the highest expected return comes from rejecting the hypothesis and accepting the existence of the environmental problem that requires remedial action. This is true even though this is a less likely outcome than that the environmental effect is absent. The reason is that the loss from one mistake is so much larger than the loss from the other.

runs all the way from *global*, for problems such as climate change and ozone depletion, through *continental*, for problems such as depletion of particular fisheries and control of acid rain, right down to *local* where, for example, one city or urban conurbation can deal effectively with the control of automobile exhaust emissions.

Consequences of Inappropriate Jurisdictions

Any environmental issue that is tackled at an inappropriate level of jurisdiction will be handled less well than it might have been. This is true either if the jurisdiction is *ineffectively* small or *inefficiently* large.

If the jurisdiction is too small, the environmental policy may be ineffective. For example, it is difficult to clean up downstream if the upstream causes of water pollution are in another jurisdiction. Similarly, attempts to clean up part of an airshed that is split between jurisdictions will accomplish much less than would be possible if the same resources were mobilized over the whole airshed.

If the jurisdiction is too large, the control that is imposed may be inappropriate for any part of the jurisdiction. This is because any given cause of environmental degradation has different effects depending on the environment in which it operates, and because environments vary across jurisdictions. For example, the capacity of the air, or a river, to handle a little more waste will be very different in a heavily industrialized, urban area, from what it is in a lightly industrialized, rural area.

Coping with Inappropriate Jurisdictions

Since it is only by accident that an appropriate jurisdiction for imposing common environmental standards will be defined by an existing political boundary such as a nation, a province, or a city, great attention needs to be paid to the jurisdictional problem when designing policies. If the jurisdiction's size is too small, then interjurisdictional cooperation needs to be fostered. This may be intercity, interprovincial, or international. In the absence of such cooperation, it may be necessary to accept the relative ineffectiveness of control at the available jurisdiction, but this should always be understood as second best, and efforts should continue to establish the cooperation needed to operate at the appropriate level of jurisdiction.

If the jurisdiction's size is too large, there is a danger of inefficiently applying standards that are appropriate for the average of the jurisdiction's areas but inappropriate for each one of the actual subareas. With the existence of many provincial and national schemes, the main danger lies in applying standards at the level that is inefficiently large. This provides one strong reason for adopting flexible market-based signals, rather than inflexible command-type rules that impose common, overall standards. To impose the same air pollution standards in a remote area of the Northwest Territories as in Toronto is almost sure to be wasteful. Any given amount of money spent on reducing emissions in remote areas, where the air has unused capacity to cope with more pollution, would produce much more human benefit if it were spent in heavily populated areas, where the air's capacity to cope with emissions is already overtaxed. Furthermore, common standards would disadvantage remote areas, which could otherwise attract industry on the basis of their lack of the need to require

expensive cleanup procedures. If the air in remote areas has the capacity to cope with some further emissions while that in urban areas does not, there is a strong argument for allocating the marginal dollar of cleanup expense to urban areas and the marginal dollar of investment in new plant to remote areas. There will, however, be no incentive to do this if common national standards for pollution emissions are enforced throughout the nation.

The Greening of Politics

Agreement over Ends

Doern points out that one consequence of the widespread acceptance of the importance of environmental issues is that all Canadian political parties will come to advocate strong pro-environmental policies. This greening of political parties means that there is unlikely to be a Canadian equivalent of the Reagan administration's decision to bypass the United States' tough environmental legislation. We should not jump to the conclusion, however, that environmental policy will not be politicized. Instead, we can confidently predict that the various parties will vie with each other over which did most when in power and which promises to do most when it gets into power.

Disagreement over Means

More importantly, parties will disagree over the appropriate policies required to deal with perceived environmental issues.

In other words, there will be disagreement over the best means to achieve commonly accepted ends.

The debate over means will be one of the major political debates of the 1990s. The political left can be expected to tend to favor the more rigid tools of the command economy — such as laws, rules, and regulations — that prescribe some types of behavior and proscribe others. The political right can be expected to tend to favor the more flexible tools of the market economy — such as pollution taxes, abatement subsidies, and marketable rights to pollute.

Although most members of the public will fully appreciate the need for environmental policies, they will be less well informed over the relative merits of alternative methods of environmental control. This almost guarantees that the debate about means will usually become partisan, often confused, and sometimes nasty. The goal of economists, and others interested in the rational handling of environmental issues, should then be to try to penetrate the often purposeful, and usually pervasive, obfuscation that accompanies partisan political battles on any issue of policy. The participants in this conference have tried their best to do so, usually from the perspective of economists who tend to favor flexible market solutions over the less-flexible command solutions. On the topic of means, the conference papers can be taken as presenting much of the case for flexible market solutions. Readers will have to look elsewhere for command solutions. Rational choice of means requires that supporters of each approach expose their views to criticisms by opponents so that the balance of argument between the two approaches can be assessed by neutral bystanders who are interested in finding the best solutions rather than in supporting one dogma or another.

Market-Based Methods of Environmental Control

The basic case for the market solution rests on its flexibility: its ability to guarantee the maximum of environmental improvement for any *given amount* spent on it, or, to view it the other way around, its ability to guarantee the minimum cost for any given amount of environmental improvement. Analysis of the causes of environmental degradation (or waste of natural resources) is based on what economists have long known in theory, and have often observed in practice: when individuals have property rights in a resource, they tend to use it less wastefully than when the resource is held in common. The foundation of most market-based techniques is to force users to calculate the social consequences of their use of a common-property resource by monetizing those consequences and imposing that cost on the firm, or to create property rights where these would not otherwise exist.

Monetizing Undesirable Social Effects

A typical method of applying the first type of solution is to levy a pollution tax. A firm that uses a river, or the air, to dispose of its waste is charged a tax for every unit of that waste. The tax is meant to reflect the social cost of the pollution, which can be the cost either of cleaning it up or of compensating those who suffer from it.[4] Firms will either spend money to remove

4 It is not always economical to eliminate pollution. Say, for example, a factory emits a nasty odor that affects 10,000 local residents and that would cost $10 million to remove. Further assume that residents would be willing to take just...

the pollution or they will go on polluting, depending on whether the cost of removing the pollution is less than, or greater than, the social cost of the pollution — provided, of course, that the tax on each unit of pollution emitted is set equal to the social cost of that unit of pollution. If the cost of removing the pollution is less than its social cost, the firm will clean up. If the cost of cleaning up the pollution exceeds its social cost, the firm will go on polluting. In this case, it will pay the tax, thus compensating the community for the cost of the pollution. As was noted at the conference, many such taxes were developed in Europe during the 1950s, particularly along the Rhine.

McFetridge tells us that these pollution taxes have not always been a great success. The main reason seems to be that the tax rates have been inflexible over time. Taxes per pound of pollution that made sense in the 1950s now diverge greatly from the current social costs of pollution. There are many reasons for this: inflation has reduced the real value of any given tax that is specified in money terms, and the real social cost of particular types of emissions has varied as the capacity of rivers and the air to cope with a marginal unit of pollution has varied over time. (The more the environment is already polluted the higher is the social cost of another unit of pollution

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...$100 each as compensation for putting up with the smell. They would thus be much happier with $500 and the smell than with no compensation and no smell. It would cost the firm $1 million — or one-tenth of the cost of removing the smell — to pay the minimum compensation that residents would accept. If the firm were to let the smell remain and pay some compensation that was more than $100 but less than $1,000 per person, then both the residents and the firm would be better off than if the $10 million were spent to clean it up.

likely to be.) These inappropriate effluent charges provide an example of the important concept of government failure.

Government Failure

Economists have long known about market failure. Whenever the market does not lead the private agents who operate in it to consider social values (as in the case of common-property resources), the market fails to do what is socially optimal. It used to be thought that the existence of a market failure was a sufficient reason for advocating some form of government intervention to remove the failure. An example would be a tax levied on polluters that is equal to the cost that the pollution imposes on the society.

More recently, however, economists have become much more aware of government failure. It is now understood that the existence of a market failure provides only the *potential* for government corrective action to improve social welfare; the possibility of government failure shows that the potential is not always realised. A valid case for government intervention requires that there be a market failure, and that the outcome be better with government intervention than without it. This is by no means always the case. For one reason, governments are often swayed by considerations of political popularity rather than social optimality. For another, public agencies set up to remove market failure are often captured by those responsible for such failure. Effluent charges that are not changed from decade to decade, and so come to bear little relation to current social costs, also represent government failures.

Bureaucratic Inertia

One major source of government failure — of which the unchanging effluent charges is an example — is bureaucratic inertia. It is often difficult for large bureaucracies to adjust to change by rapidly altering their behavior. (The theory of why this should be so — and the evidence that it often is so — is to be found in the voluminous modern literature dealing with the behavior of institutions.) Bureaucratic inertia provides another strong reason to choose from among the alternative, market-based techniques for dealing with environmental problems — techniques that leave as much as possible of the adjustment to change in the hands of individual market agents, acting on incentives provided by governments, and as little as possible to conscious adjustments made by government administrators.

The Creation of Property Rights

The second main type of market-based technique is to create property rights where none are naturally provided. A good example (and there are many) is the transferable right to pollute that many U.S. states have adopted. The need for flexible adaptations to continually changing situations provides a powerful reason for using transferable rights to pollute rather than taxes on polluters or subsidies to those who clean up their pollution. Although the details can become quite complex, let us look at the essence of this environmental tool.

Consider, for example, an important export industry that is the source of some undesirable air pollution caused by smokestack emissions. The industry contains many firms,

operating many plants of different vintages. The expenditure required to reduce a ton of smoke emissions differs greatly among the plants.

Now assume that the government wishes to reduce the industry's smoke emissions by one-half. The most extreme, command solution would require that each plant cut its emissions to an amount equal to one-half the industry average.[5] In this case, much money would be spent on reducing emissions from those plants where the cost of reducing emissions is large, while less would be spent on plants where the cost of reducing emissions is low.

Now assume that instead of requiring each plant to meet the industry pollution average, the government issues transferable rights to pollute, equal in total to one-half the industry's present amount of pollution. It either sells, or gives, these rights to firms in the first instance and the rights are then salable among firms. The price of the right to emit a ton of pollution will tend, in this example, to equal the industry's average cost of removing a ton of pollution.[6] Firms whose costs of removing pollution are less than the industry average, and hence less than the price of the pollution right, will clean up. Firms whose costs of cleaning up exceed the industry average, and hence exceed the price of the pollution right, will buy the

5 A less extreme version would dictate that each company hold its overall emissions *per unit of output* to a level equal to one-half the industry average. This rule would leave each firm free to reduce pollution where the costs are least. However, it makes no allowance for reallocating pollution abatement among firms so as to minimize the cost of meeting the abatement target.

6 The larger the amount of pollution abatement that is required, and hence the fewer the rights to pollute that are issued, the higher will be the free-market price of the pollution rights. In the limit, when only the right to emit only one ton of pollution is issued, the cost will be just less than the highest cost of removing any ton of pollution in the whole industry.

rights and continue to pollute. The outcome is that the government's pollution-abatement targets will be met at the lowest possible cost to the industry.

Compared with the command solution, which calls for the same smoke emissions from all plants, this market-based solution is preferable to the firm's employees (because it minimizes employment losses), to its customers (because it minimizes the increase in the product's price), to its owners (because it minimizes the reduction in profits), and to the whole economy (because it minimizes both the amount of scarce resources used in achieving any given amount of pollution abatement and the loss of international competitiveness due to the raising of export prices to cover the abatement costs).

Resistance to Market-Based Methods

Despite the powerful case for market-based methods, advocates of this approach encounter much resistance. The groups who resist such solutions often include firms, ordinary members of the public, and environmentalists. What can be said about the reasons for this resistance?

Firms

Perhaps the most surprising source of opposition to market-based solutions comes from the management of many firms. Several reasons for such opposition may be suggested.

Fear of a tax grab: Some firms object to the costs that they are asked to pay in terms of emissions taxes or the purchase prices

of pollution rights. They sometimes see these as government tax grabs. Here it is important to distinguish between the costs of dealing with the environmental problem in general and the extra costs that may or may not be associated with a particular method of dealing it.

There is no reason why payments to government under any market-based scheme need be a tax grab. They need not be in excess of the costs imposed on society by the industry's activities. If government uses the introduction of a market-based scheme to raise general revenue, firms can oppose the extra tax burden without needing to oppose the market-based scheme itself. So any tax-grab aspect that might occasionally be present can be separated from the other aspects of any scheme by considering only those payments by industry that equal the costs that its activities impose on society. In order to avoid confusing hostility to additional taxes with hostility to specific market-based environmental schemes, however, government should be careful not to use such schemes as general money raisers.

Resistance to bearing legitimate costs: Typically, when new environmental policies are to be put in place, firms are required to bear some, or all, of the environmental costs that their activities have been imposing on society. This means that the introduction of market-based, antipollution measures may signal the end of a free ride that producers have been taking at society's expense. If the industry was polluting, and bearing none of the cost of this pollution, then almost any antipollution scheme will impose a burden on producers — but only to the extent of forcing them to bear a cost of their own activities that

they have been passing on to the society at large. Just as it is not unreasonable to ask firms to pay for what they use by way of labor and materials, so is it not unreasonable to ask them to pay for what they use by way of resources, such as air and rivers, that are generally available to society.

Thus, firms need to accept that any move to clean up their industry's pollution will impose costs on them. The difference between the command solution and the market-based solution, however, is that the former will cost the industry as a whole, and hence the average firm in the industry, more than the market solution — and can often cost every firm much more. With effluent taxes, the firm has the choice of paying the tax or cleaning up the effluent — whichever is the cheaper; with the command solution, the firm must pay the cleanup bill no matter how high it is. Similar considerations apply to pollution rights. No firm needs to buy them; a firm only does so if the costs of the rights are less than the costs of the cleaning up that it would have to do anyway under the command solution. Whether or not a few firms pay more under the market-based solution depends on the precise form of the scheme. However, since firms pay less on average, it is not beyond human wit to design schemes where all firms pay less.

Concern over inequality: All practical market-based schemes do not ensure, however, that all firms pay less than under a command scheme, only that the average firm does. When some firms pay more, there is another source of firm opposition. Some oppose the measures out of a feeling of injustice that they must pay more than under alternative schemes. Others oppose it because they have to pay more than some of their

competitors. The redistributions of income and profits caused by market-based schemes are often a source of resistance. It needs to be noted, however, that command solutions also have differential impacts on firms, hurting those with the largest costs of cleaning up relative to those with lower costs.

Concern over fairness: Finally, under market-based schemes, many firms feel a sense of unfairness because their competitors continue polluting while they must clean up. Their complaints, however, fail to allow for the fact that those who continue to pollute have paid for the right to do so, either by paying effluent taxes or by buying pollution rights, and that the complaining firm could do the same if it wished to (and does not do so because cleaning up is cheaper for it than paying to pollute as their neighbors are doing).

A sense of unfairness can be very potent, even when it is illogical in the sense that what is happening is less unfair than what would happen under any alternative scheme. This points to the key issue that must always be kept in mind when trying to persuade firms of the advantage to them of market-based solutions: that such solutions must not be judged in isolation. Given a government's decision to reduce pollution, the market solution must be compared with its alternatives. When this is done, many of the reasons for producer opposition fade away because of the realization that such things as the tax bill, the inequality in the relative burdens among firms, and the inequality in each firm's own absolute increase in costs are all less in the market-based than in the command solution. (If this is not the case, at least for the vast majority of firms, then those who designed the proposed market-based solution should think again; it is almost certain that they can do better.)

The Public

Opposition from the public can develop for a number of reasons. Here are just a few that seem important.

Hostility to the market: One reason is a general hostility to market-based solutions and a preference for government-imposed solutions, an attitude which differentiates Canadians from Americans — at least according to many authors.[7]

Pollution is morally wrong: A second source of public opposition is a moral reaction to giving anyone a right to pollute. Many see environmental control as an issue of the heart. Since it is about human survival in the final instance, dealing in rights to pollute is like dealing with some form of evil. The problem with this view is that it makes it hard to evaluate, in a rational way, alternative plans for dealing with what everyone agrees is a serious enough problem to be termed — if one wishes to use such words — a social evil.

The worst polluters may end up still polluting: A further important source of opposition is found in the market-based solution's characteristic of allowing those who have the highest costs of cleaning up to go on polluting while with the lowest costs do the cleaning up. This is socially efficient in the ways

7 See, for example, Seymour Martin Lipset, *Continental Divide: The Values and Institutions of the United States and Canada* (New York: Routledge, 1990).

outlined above, but its visible effect will often be that the oldest plants, with the most visible pollution belching forth, will continue to pollute, while the newer plants, which are less obvious sources of pollution in the first place, are the ones who eliminate their pollution. It may be futile to point out that it is efficient to have those who can clean up most cheaply do so; morality may dictate to many observers that the biggest and most obvious polluters should do the cleaning up. (Faced with this reaction, economists cannot show it to be wrong; they can only point out the cost in terms of the higher prices, lower employment, unnecessary resource use, and less overall pollution abatement that follow from adopting such a moral position.)

Environmentalists

McFetridge, in particular, notes environmentalists' frequent opposition to market-based solutions — their opposition is undoubtedly the strongest of the various groups mentioned. A few of the most important reasons for this opposition are worth emphasizing.

Fear that markets are not efficient: First, environmentalists often doubt the efficiency of markets. Some do not understand economists' reasoning as to why markets can be, and often are, efficient in their use of resources. Others understand the economists' case but reject it. (For those who reject this case, however, it is not enough to argue that markets fall short of perfect efficiency. Few environmentalists bother to complete

the argument by trying to demonstrate that command-type allocation by government will be more efficient.)

Dislike of self-interest incentives: Second, many environmentalists do not like the use of self-interest incentives to solve great social issues. One of economists' greatest insights is that people do respond to self-interest incentives and that, in the long term, such incentives dominate behavior in ordinary matters. Economists who point to the voluminous evidence of the importance of self-interest incentives are often accused of totally ignoring higher motives such as social duty, self-sacrifice, and compassion. Although such motives are absent from the simple theories that try to explain the everyday behavior of buyers and sellers (because it has not been found necessary to introduce such motives into these theories), economists since Adam Smith have been aware of their existence and power. (After all, Adam Smith wrote *The Theory of Moral Sentiments* as well as *The Wealth of Nations*.)

As I understand the evidence, other motives, such as altruism and devotion to a cause higher than one's own self-interest, often do exert strong influences on human behavior. Furthermore, many people derive satisfaction from belonging to some group such as a club, a fraternity, a city, a community of nonpolluters, or a nation. Such people will sometimes sacrifice their self-interest for that larger entity — as, for example, in time of war.

Such "higher" motives are very powerful at some times and in some situations, but they do not govern many people's behavior in the course of day-to-day living. In ordinary affairs, self-interest explains most of human behavior, particularly in

such simple economic matters as buying and selling.[8] If we want to understand how people behave in the aftermath of a flood or an earthquake, we will need motives in addition to self-interest; if we want to understand how people behave day after day in their buying and selling, we need little other than a theory of the self-interested responses to market incentives. Adam Smith knew a lot about the importance of altruism in certain circumstances. His point, however, is that we do not have to rely on altruism to persuade the baker to provide us with bread, or for others to get on with their day-to-day tasks that make the economy function. Fortunately, their self-interest leads them to provide us with our bread and other commodities.

Many feel that to rely on the motive of self-interest in respect to pollution (and conservation) is to degrade a matter of life and death. It is important that we do everything to persuade such people that the enormous weight of evidence is that, although altruistic motives can sometimes be important, or even dominant, altruism cannot be relied on to guide the myriad day-to-day decisions that ordinary people must make to guide their economic affairs. Since control of the environment requires influencing this mass of small decisions, as well as a few large ones, the appeal to self-interest is the only currently known way to induce the continual behavior that we require. Once this is accepted, what remains is to choose between relying on the self-interest of fear of penalties required

8 There some notable exceptions. For example, many consumers refuse to buy South African goods even when their prices make them attractive. In spite of this altruistic behavior, the same consumers tend to chose from the rest of the available commodities on the basis of self-interest, taking such factors as price and quality into account.

by the command approach and the self-interest of pursuit of gain when market-based approaches are used.

Wrong tradeoffs between present and future: Another reason why many environmentalists reject market-based solutions is their belief that the market cannot be relied on to get the tradeoff between present and future right. For example, there is always a question of how much oil to extract today and how much to leave in the ground for future use. Critics of relying on the free market to set production rates for resource products often assume that the market will exploit a resource too fast, so that government intervention is needed to conserve the resource for the future. This involves a complicated argument that we cannot go into here. Two points are worth making, however. First, although market failures in rates of extraction are possible — by extracting too quickly or too slowly — no one has succeeded in proving a general tendency for the market to extract resources too quickly. Second, the assumption that governments, dominated as they so often are by considerations of the next election, will nonetheless take a longer view than the market can only be described as a touching act of faith. One has to look no further than the Hibernia project for an example of the Canadian federal government's proposing to extract now a resource that would some day be valuable but that is today worth a negative amount — an amount which taxpayers will have to put up before firms will be willing to extract the oil, and before society will be willing to use it.

A mystical view of resources: Finally, many environmentalists have a somewhat mystical view of resources as being above

mere monetary calculation and that they should thus be treated in special ways. It is hard to argue rationally with religious positions. One can only point out that the use of the mystical view to justify departing from market solutions, and from solutions based on calculations of market failures (which are measured in terms of failure to provide maximum economic value) ensures that measured material living standards will be lowered. If that is the understood, and accepted, price of regarding resources as mystical entities, then so be it!

The Design of Market-Based Mechanisms

By Firms

Finally, many speakers at the conference addressed the question of what needed to be done to get market-based methods of control into fuller use. Normal Ball suggests that companies could take the initiative themselves. This presents one, perhaps way out, possibility to me, but it might just be worth considering.

Business often complains that government measures are badly designed and more cumbersome than they need to be. The solution might be for an industry that sees the inevitably of some environmental control being imposed on it to design its own scheme. For example, the industry itself could design a system involving transferable rights to pollute. In the first instance, the voluntary reduction in pollution need not be great. All that is needed is just enough to make the system have enough bite to provide a satisfactory experiment — possibly a 5 percent reduction might be enough. The industry could get the system right by its own efforts, refining its design

until it was as good as the firms in the industry could make it. Inertias are such that, once the government decided to step in, it would be likely to adopt the system already in place rather than to expend the time and effort needed to design a wholly new system.

Firms might argue that designing such a system would encourage government intervention and that they would do better by staving off the inevitable day through resisting all moves to regulate environmental effects as long as possible. But if there is confidence that the industry itself can design a better system than can government officials, there must be some acceptable tradeoff between having a better system adopted a little earlier and having a worse system imposed a little later.

By Economists

Economists who advocate market-based solutions need to work hard at designing specific systems that are appropriate to particular markets. For example, transferable rights work best when there is a large number of producers, so that the market for the rights is reasonably competitive. If there are a few firms in an industry, the market for the pollution rights will be thin and may be dominated by one or two firms. Economists will need all the ingenuity that they can command if they are to design market-based solutions that will be effective in oligopolistic industries, and other specific situations that differ greatly from the ideal situations found in the classroom. Many a good idea has been discredited because it was tried out in a faulty scheme that failed to realise the idea's potential. Without a lot of patient work, ideas for market-based

techniques for environmental control may be discredited by results that really reflect faulty design or (as in the case of rigid effluent charges) government failure.

Economists who support market-based solutions also need to work hard at creating, and sustaining, a dialogue with opponents, particularly environmentalists. Only then can there be any hope of persuading some opponents of the value of some of the insights of economists — such as the importance of relying on self-interest incentives.

Conclusion

Environmental protection and appropriate amounts of resource conservation are two of the most important issues facing the world today. Our future material welfare will be greatly affected by how well, or how poorly, we deal with these matters. How well we do deal with them will be tremendously influenced by the outcome of the debate on the relative advantages of market- and nonmarket- based methods.

Nineteen eight-nine saw one of the most momentous events in modern history. The people of the eastern European countries voted with their feet, by their presence at rallies, and sometimes with their lives, against central planning as a way of organizing economic affairs and against one-party dictatorships as a way of organizing political affairs. Those countries are now moving rapidly toward a system of free markets to manage economic affairs and multiparty democracies to manage political affairs. There will be many a slip between their starting off on this adventure and their completing the transition to market-based economies and popularly based democracies. But there will be no going back to planned economies.

One of the main sources of failure of planned economies is their inflexibility: their rigid command structures could not cope with change and novelty. As a result, they could deliver neither minimally acceptable — or even modestly growing — living standards, nor environments with pollution levels anywhere near as low as those that we rightly complain about in the West.

It would be a tragedy, and a great historical irony, if, immediately after the conclusive demonstration of the superiority of free markets over central planning as alternative ways to organize our economic affairs, the countries that enjoy the benefits provided by free markets were to turn their backs on their experience by adopting the rigid, and discredited, tools of central planning to deal with their environmental crises. Those who understand the lessons of the failure of the eastern European economies need to do everything they can to persuade the citizens of western nations of the folly of trying to centrally plan our desperately important environmental adjustments.

The danger is, however, that the idea of centrally planning our environmental effort will have the same seductive appeal as had the ideas that captivated generations of socialist thinkers into believing that decentralised market competition was inefficient while coordinated centrally planned monopolies were efficient. As most of the participants in this conference have acknowledged, however, large bodies of economic theory and factual observations attest to the superiority (in most places, most of the time) of flexible systems that allow for market-based adjustments based on self-interest responses to economic incentives over inflexible systems that require command-determined adjustments based on responses to orders

or appeals to altruism. This superiority is as applicable in producing high rates of adaptability to environmental change as it is in producing a similar adaptability to economic change.

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Market Approaches to the Greening of Canada

G. Bruce Doern
Editor

At last, environmental issues are entering the public policy mainstream. Yet the desire to "do something" has not led thus far to any consensus about the appropriate ways to deal with the problems. There is an understandable reluctance in many quarters to entrust the solutions to government and to "command-and-control" approaches, but business also needs to understand the concerns of the environmental movement.

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